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DISCOVERY

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RICHARD ALDINGTON: SCIENCE & CONSCIENCE

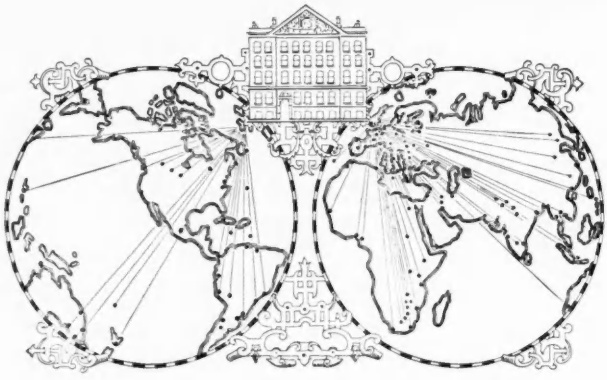
● MR TOMPKINS IN WONDERLAND

● The Confidence Drug

● Modern Street Lighting

● The Super Microscope

ONE SHILLING NET



NEWS FROM ABROAD

THERE are 299 countries listed in an up-to-date Atlas. How is a daily newspaper to deal with the events in all of them? The methods adopted by different newspapers vary. One method is to ignore the outside world until circumstances force some particular place "into the news." Then, perhaps, a famous correspondent may be sent post-haste to investigate, to gather and report his impressions on the spot.

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THE TIMES

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SCIENCE & CONSCIENCE

A Letter from Mr Richard Aldington

SIR,—Lord Rayleigh's Presidential Address, parts of which you reproduce, seems to have given universal satisfaction and to be taken as a complete refutation of criticism directed against the attitude of scientific men towards the results of their labours.

But is it so satisfactory as all that?

If scientific men accept Lord Rayleigh's plea that they are in no way responsible for misuse of the knowledge they have secured, they must also disclaim any merit for the benefits it has conferred. They cannot have it both ways. If they are pure seekers after knowledge, utterly unable to control in any way either what they discover or what is done with their discoveries, then they have no right to boast themselves the benefactors of humanity. Or are we to thank them humbly for chloroform and blame mustard gas on the Army Council?

Perhaps scientific men, who are not wholly averse from self-laudation, will consider this point.

But the scientific world is not limited to the vanguard of distinguished researchers. It includes all teachers of science and all technicians who receive that teaching. Without their collaboration the application of science to industry and to war is impossible. Have they ever been known to refuse it, whatever the consequences to common humanity? Has it ever been suggested by their great leaders that there is a moral obligation upon them, such as is rightly laid upon doctors by the oath they are compelled to take, to use their knowledge for the benefit and not the destruction of humanity? Further, is there any known case of a scientific technician

who has refused to put his skill and knowledge at the disposal of governments and the military, even when he was fully aware that his gifts were to be misused for the destruction of his fellow men? Unscientific men have submitted to torture and death rather than commit these crimes. But Science and Lord Rayleigh are comfortably neutral.

I would suggest that every man or woman taking a scientific degree might, as a start, be required to take the oath of Hippocrates or some more suitable variation.

The present state of affairs is as if the Catholic Church should say: "The Apostles and the Doctors have preached and thereby conferred immense benefits, but we disclaim all responsibility for the conduct and doctrine of the inferior clergy, and what the laity do about the Faith is no responsibility of ours either. But, rather unhopefully, we will set up a Committee to see if anything can be done."

Without the co-operation of the technicians—the inferior clergy of Science—the conduct of scientific warfare is impossible. It is the duty of the leaders of the scientific world so to organize themselves and their pupils that such co-operation is withdrawn.

I can imagine a common man of the people musing over Lord Rayleigh's speech in terms such as these:

"A few weeks only have passed since we were all threatened by a war of unprecedented destructiveness. That destruction, if it had occurred, would have been almost wholly due to the application of science to warfare. Thousands of scientific technicians would have given their labours and knowledge to destroy civilization. And Pontius Pilate, F.R.S., washed his hands."

Yours faithfully,

RICHARD ALDINGTON

NOTE BY THE EDITOR

ANYONE who knows Mr Aldington's novels or poems will treat his challenge with respect; for he is a great defender of that humanism which is one of the highest achievements of our civilization, and which is now in danger of being driven from the world. And, in fact, many scientists will read his letter with sympathy and a feeling that they are in close agreement. We tried, in the October number of *Discovery*, to express a representative scientist's view of "Science and a Modern World"; and between that view and Mr Aldington's there is no difference of ends, only of means.

Two points stand out clearly in his letter.

1. Scientists must not claim merit for the benefits of science if they disclaim responsibility for its misuse. That is unanswerable. It has perhaps not been said so cogently before. But "Science is non-moral" we wrote in the October number;

and the credit or blame for its applications lies equally with society. Science *makes possible* both the destruction of Guernica and the new cures for pneumonia. Any scientist who congratulates himself in the second and is complacent about the first deserves everything Mr Aldington says.

The only judgment we can make is a purely workaday one. It is probable that, when we consider both the good and evil applications of science, mankind has gained materially on the balance.

The average length of life, for instance, has increased, even allowing for deaths in scientific warfare; more years of life have been added to the race by modern medicine than have been taken away by modern armaments. Similarly, most people on earth are still living lives of great poverty and continual toil; yet science has enriched them a little, though nothing like as much as lies within its power. Science has brought about the monotonous days of the factory worker; yet the factory worker has a richer, more variegated and leisurely life than the peasant of a pre-scientific age.

That is as much as a scientist can reasonably say. Far from justifying any complacency, it ought to leave one no rest until society is using science as it could be used.

2. Mr Aldington's second point, the responsibility of the individual person with a scientific training, is not so straightforward. His idea of an equivalent to the Hippocratic oath has been floating in the air of some sections of the scientific profession. This summer *Nature* published an "Oath for Modern Man" which meets many of Mr Aldington's requirements. But, as we said in the October article, it is in the highest degree unlikely that such an oath will be taken, or adhered to, on a scale large enough to restrict the destructive applications of Science.

To that statement Mr Aldington asks "why?" with the generous indignation of someone who is seeing splendid hopes perish. Why cannot scientists prevent the perversion of their work? The reasons are rather complicated. It is not that scientists are more selfish than the general run of people; they are no more than human, but they are also no less. In their own field, many scientists and scientific technicians, from the most eminent creative workers down to unpretentious laboratory attendants, have risked and sometimes found martyrdom: in research on radio-active substances, or tropical diseases, or new unstable chemical compounds, there have been a good many lives lost and bodies wrecked, and those risks were undertaken in full knowledge of what might come; not to speak of men like Giordano Bruno, who died rather than deny the truth.

There are still present in the world to-day many scientists who take necessary and mortal risks as part of their everyday work. There are also a few, not enough, but still a few, who would die rather than deny what they know to be scientific truth.

Yet, as Mr Aldington says, "is there any known case of a scientific technician who has refused to put his skill and knowledge at the disposal of governments...,

even when he was fully aware that his gifts were to be misused for the destruction of his fellow men?" There are a few, in fact, but all inspired by a completely pacifist faith. It is a faith of that sort, quite irrespective of their being scientists, which moves them; and if we think out the problem, we realize that only complete pacifism would hold a scientist to the course of action Mr Aldington calls for.

It might be different if there existed a world scientific organization, which all scientific workers of any kind whatever were compelled to join. If this existed, it might enforce its own ethics on its makers, and it might induce them to recognize their first loyalty to its code rather than to that of any other section, such as nation or class. But the existence of such an organization lies very far in the future; it will not come about until the world is nearly ready to become one state.

But, even if it existed precariously in our anarchic world, it would still not really meet Mr Aldington's purpose; for it would be far too easy to blackleg, both from within and without. The technicalities of scientific warfare do not require the greatest scientists for their invention, nor does it require a long training to be able to apply them. Many people have a smattering of technical science nowadays, from their motor-cars and wireless sets. It is not such a holy mystery as some scientists like to pretend. If by some utopian miracle the world organization of science happened overnight and every technician held to his promise to keep aloof from military work, within a couple of years the world would raise enough substitutes to be ready for scientific warfare in its uncrippled rigour.

The world profession of science is a dream in our day, and must remain so while the world is passing through its present confused economic state. And thus, if Mr Aldington's non-co-operation is to happen at all, it will have to happen in one country and not in others: which means that it can only come from pure pacifists and from no one else.

Let us consider a war against Germany. We know that there are at least enough scientists and technicians in Germany to let their state conduct a modern war; we are certain that they cannot be persuaded not to co-operate, and in fact that they are co-operating already with considerable energy. English scientists are then faced with the problem: are we to fight against those scientific weapons with similar things that we help to make ourselves?—or are we to stand aloof, to dissociate ourselves from society, to face our own discomfort and worse, the helplessness of our particular form of civilization, rather than allow our knowledge and skill to be turned to the killing of other human beings?

It is only possible to make the latter choice if one thinks war is the greatest evil. For anyone who feels there are even worse things, there is no option but to take part, preferring a hateful function because otherwise a more intolerable evil will come about. Mr Aldington fought in the line from 1915 to 1918. Scientists will not be asked to fight; they will be preparing means of destruction, at little risk to themselves. But they can compare themselves with him in this respect; they will find it impossible to extricate themselves from the war.

The Super Microscope

By Gabriele Rabel

(Dr Rabel's notes are already familiar to readers of Discovery. *This article makes us acquainted with the latest development of the microscope—by means of which we can now* see *the detailed structure of some of the disease-producing bacteria.)*

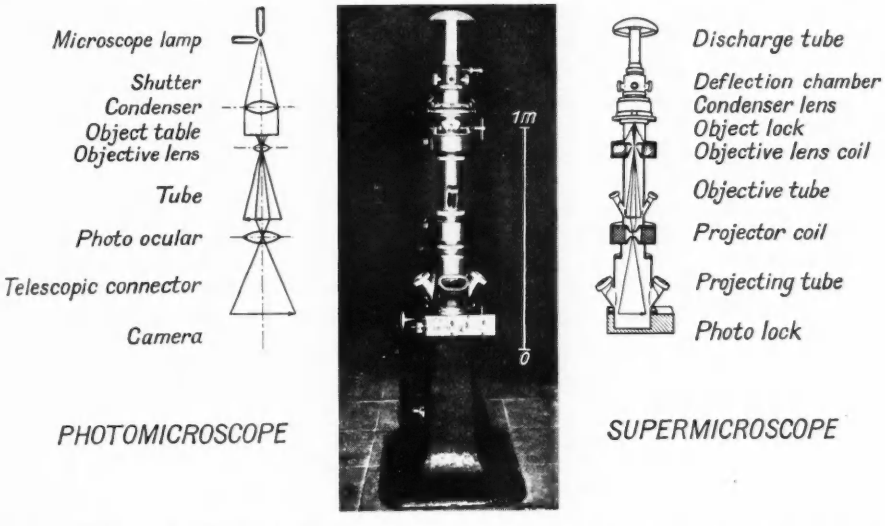
The super microscope has opened the realm of colloidal dimensions to the human eye. Structures which could hitherto only be distinguished by their different behaviour towards stains are now directly visible without application of any staining process. Particles with hardly double the diameter of albumen molecules, disease-producing agents which before could only be separated by physico-chemical serum or toxin reactions, can now actually be seen and their forms distinguished.

Magnifications up to the order of 20,000 are attainable.

Such are the feats which B. von Borries, E. Ruska and H. Ruska triumphantly proclaim as the result of their investigations (*Klinische Wochenschrift*, July 1938).

The super microscope is based on the following principle:

If a current-carrying electric conductor is movable, it is, as every schoolboy knows, displaced by a magnetic field. In the same way, free electrons or beams of electrons coming from a cathode are deflected by a magnetic field. This property has been exploited for optical purposes, and a new branch of optics or electricity termed "electron-optics" has developed from it. A magnetic field produced by a coil acts on electronic rays as accurately as an optical lens acts on the rays of light, and "magnetic lenses" are combined in the electron microscope as the optical lenses are in the photomicroscope. The super microscope is the newest development of this type of instrument.



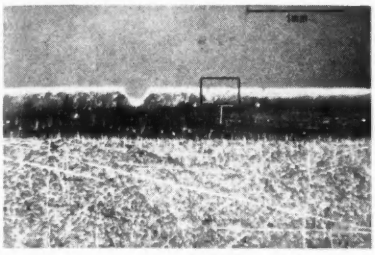
THE CONQUEST OF THE INVISIBLE WORLD.

Aids to Vision	Resolving Powers attained by different aids to vision compared. Range of Sizes.						
	1 mm.	0·1 mm. =100 μ.	0·01 mm. =10 μ.	0·001 mm. =1 μ.	0·0001 mm. =100 mμ.	0·00001 mm. =10 mμ.	0·000001 mm. =1 mμ=1 μμ.
Eye	Thickness of a coin	Thickness of a razor blade					
Magnifying glass, 1000 A.D.			Structure of tissues				
Microscope 1650 A.D.			Life in a drop of water	Cells, tissue fibres, bacteria			
Ultraviolet microscope, 1904					Small bacteria, large viruses		
Supermicroscope today					Inner structure of bacteria, large colloids, viruses	Small colloids, giant molecules	
Further development of supermicroscope							Albumen and organic molecules

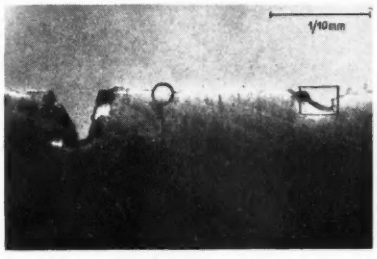
The path of the electrons through the lens is rather complicated. In every single point of the curve the component of the magnetic field, which is perpendicular to the momentary direction of the electron, acts alone and produces a force perpendicular to both the magnetic field and the direction of the electron. Thus a curve originates which from point to point changes its direction in space and winds spirally around the axis of the coil.

The magnetic lenses have no definite focal distance. Altering the coil current alters the force of the magnetic field and, consequently, the focal distance of the lens. As the focal length varies, the electron-optical image not only becomes more or less sharp, but, in accordance with the spiral ray deflection, turns on itself, i.e. around the optical axis.

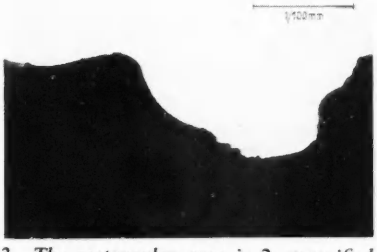
In its main features, the electron microscope can be compared with the photomicroscope, with one exception: in the photomicroscope the source of light is, as



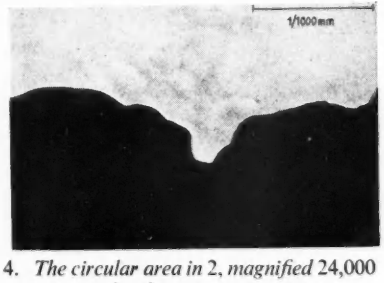
1. *Notches in the edge of a razor blade magnified* 20 *times*



2. *The rectangular area in* 1, *now magnified* 200 *times*



3. *The rectangular area in* 2, *magnified* 2000 *times by the photomicroscope*



4. *The circular area in* 2, *magnified* 24,000 *times by the super microscope*

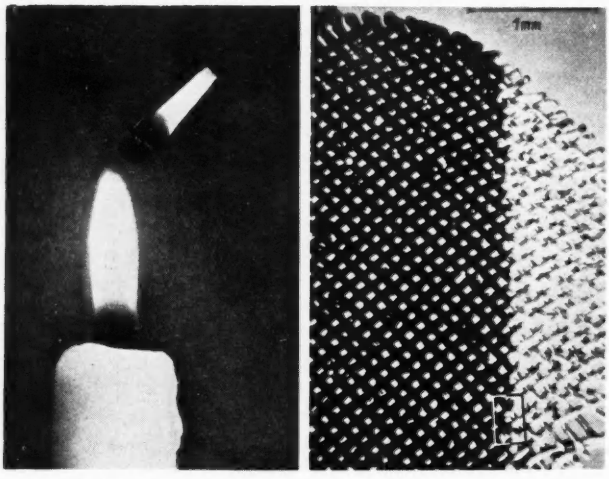
a rule, at the bottom and the ocular lens at the top of the device; taking this arrangement as normal, we must call that of the super microscope topsy-turvy—for the cathode which carries the high tension is above the head of the observer. From the cathode the electron beam falls downward perpendicularly, ending on a luminescent screen which makes the image directly visible to the eye, or on a photographic plate.

First the beam is collected by a "lens" which corresponds to the microscope condenser. Then it illuminates the object. The condenser can be shifted to all sides, thus enabling the beam to be exactly focused on to the object. Then follows the "objective" which projects a real image of the object in first stage magnification on an "intermediate picture screen". This screen has a hole through which part of the image can continue its way downwards. It is then magnified to the second stage by a "projector lens" and appears as the final image on the lower luminescent screen or photographic plate. Lateral openings in the tubes allow a view of the intermediate image which shows the whole preparation in minor magnification, and then of the final image which shows the details. During observation, the object can be shifted so that any desired part can be projected on the final screen, and it is also movable in the direction of the axis for focusing purposes. A photomicroscope is also fitted in such a way that the two microscopes can be exchanged without moving the object out of its well-focused position, so that the two pictures can be compared at any moment.

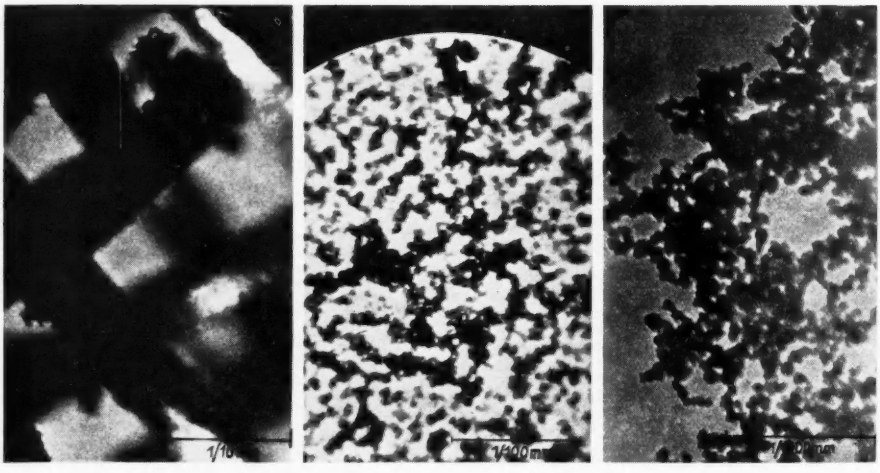
Since electron beams can only exist in a vacuum, the whole apparatus must be kept evacuated. Both object and camera can be inserted and exchanged without disturbing the vacuum.

The electron-optical pictures show different degrees of blackening. That is due to the fact that the electrons, which fall upon the object almost parallel, are then scattered to different degrees in proportion

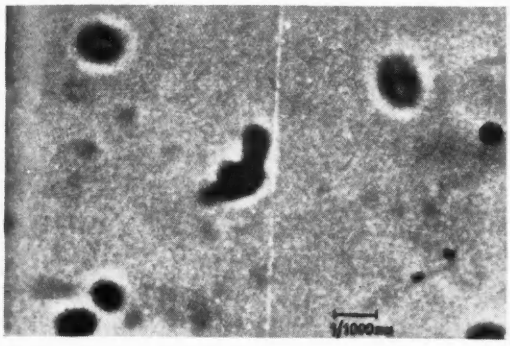
Soot is the fundamental substance for numerous technical and chemical processes and is used in the making of many synthetic materials. Not every kind of soot is serviceable. Its structure, which can now be recognized, determines its applicability.

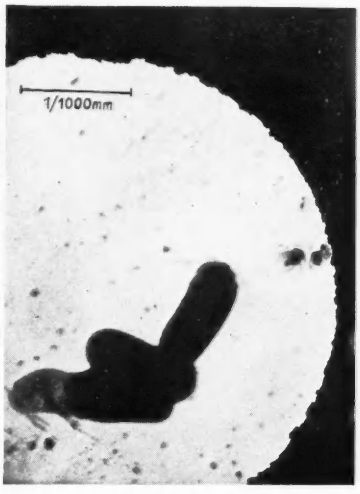


1. *Natural size. Sooting of a silver wire by means of a candle.*
2. *Magnified* 20 *times, the boundary of the blackening is clearly seen.*



3. *Magnified* 200 *times, the single soot flakes appear in the loops of the net.*
4. *Magnified* 2000 *times by the photomicroscope, with the strongest objective lenses, fine ramifications of the flakes can be seen.*
5. *In the* 24,000 *magnification by the super microscope it can be noticed that the branches are composed of small hexagonal scales, and so the physical properties of soot can be described.*

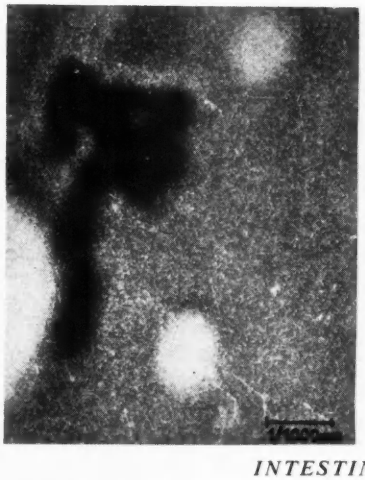




DIPHTHERIA BACILLI

1. *Magnified with the photomicroscope* 1000 *times, with seven subsequent magnifications, final magnification consequently* 7000. *Owing to the subsequent magnifications the picture loses in sharpness.*

2. 18,900 × *magnified electron-optically.*



INTESTINAL BACTERIA

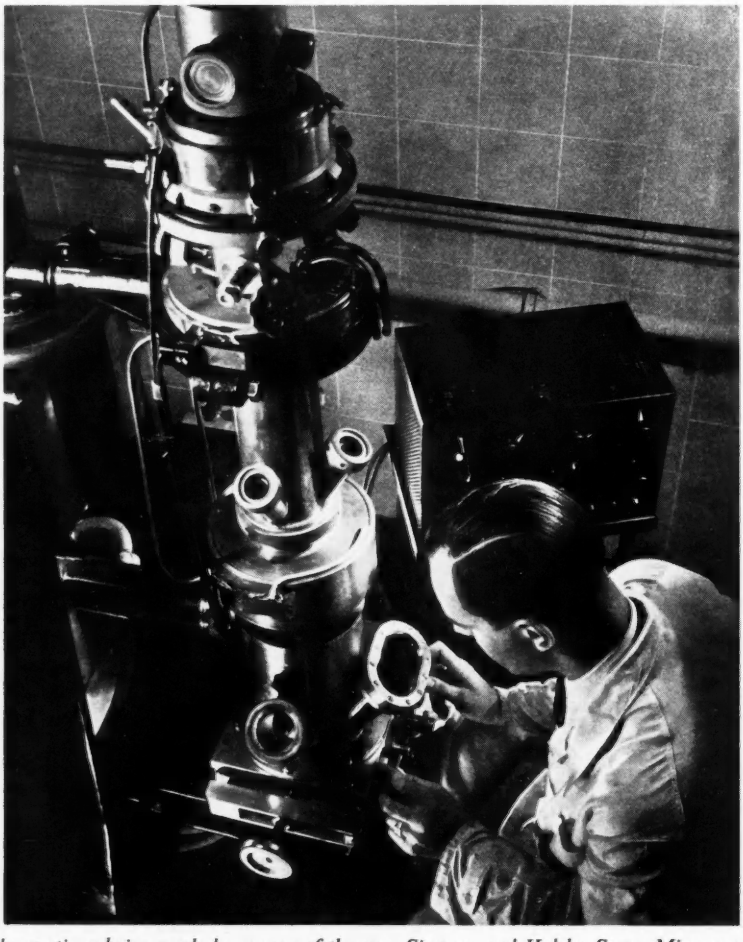
Left part of the picture:
1000 × *magnified with photomicroscope, then subsequently magnified to* 10,000.

Right part of the picture:
4200 × *magnified with electron microscope, then subsequently magnified to* 10,000.

The final magnification is the same in both cases. But the super microscope shows a much sharper picture and many more details of the bacterial structure and of the surroundings.

to the "mass thickness", i.e. density × distance which the rays have to travel through the object. The greater the mass thickness, the greater the scattering. The rays scattered through a larger angle are not allowed to pass completely through the very small aperture of the objective. Parts of the object having a greater mass thickness, therefore, appear darker, as they obviously would if they could be inspected in ordinary light. In this manner the electron-optical picture reveals the distribution of mass in the object. Thus it is possible, for example, to distinguish features within the bacterial body which otherwise could not be seen at all or only by staining.

Various bacteria and viruses have been examined in this way by Borries and the two Ruskas, and the finest details of their structure were revealed to them. To give particulars concerning these results would perhaps be of interest only to specialists. But we may trust that the super microscope will, in the near future, considerably enrich our knowledge about cells and their nuclei, and about chromosomes and genes.



Observations being made by means of the new Siemens and Halske Super Microscope

Mr Tompkins in Wonderland

Professor G. Gamow, one of the younger generation of Soviet scientists and now professor of theoretical physics at George Washington University, is known throughout the scientific world for his original work on the theory of atomic nuclei. He is also known for having included, among his profound scientific contributions, specimens of an odd and characteristic humour; it is not very often one meets jokes in the middle of a scientific paper.

"Mr Tompkins in Wonderland" combines Professor Gamow's deep knowledge of modern physics with his particular brand of humour. It is an attempt to explain, by a series of stories, the new ideas of space and time.

Professor Gamow himself writes (but this letter will be more easily understood after one has read his first story):

The fact that in ordinary life the classical notions of space and time can be used as a very good approximation is due to specific numerical values of different world-constants in our Universe, such as velocity of light, constant of gravitation, quantum-constant, etc. If we imagine other worlds with the same physical laws, but different numerical values of constants, the relativistic and quantum phenomena would be easily accessible to observation. We may say that even the primitive savage in such worlds would be acquainted with relativity and quantum principles, using them for his hunting purposes and everyday needs. In the following stories a certain Mr Tompkins, who does not know any mathematics or physics, being a clerk in a city bank, is brought in his dreams into different worlds of such types where he can directly observe the phenomena about which modern science concludes only from very elaborate investigation.

The Author hopes that the experiences of Mr Tompkins will help the reader to build a clear picture of the world in which we are living.

Dream I: Toy Universe*

MR TOMPKINS, the little clerk of a big city bank, was very tired. The whole day's work of adding the infinite columns of bank accounts had brought his mind to a state of blank dullness. He definitely needed some distraction. Picking up an evening newspaper he opened the movie-theatre page. None of the films, however, looked attractive to him. He detested all this Hollywood stuff with infinite romances between the popular stars. If there were at least one film with some real adventures, with something unusual and maybe even fantastic. But there was none. Unexpectedly, his eye fell on a little notice in the corner of the page. The local

* The universe described below corresponds to a velocity of light ten million times smaller, and a gravitational constant a million million times larger than in our universe. The radius of the universe in the state of largest expansion is about a hundred miles and the corresponding density of dust about 1 lb. per cubic mile. The period of pulsation of the universe is in this case about 2 hours. The density of the rocks is the same as on the earth.

university was announcing a series of lectures on the problems of modern physics, and to-night's lecture was to be about the problems of Space and Time and Cosmology. Well, this might be something! He vaguely remembered that in his youth he had read a book about an adventurous astronomer travelling in a rocket-ship through interstellar spaces, visiting different planets and even some distant stars. Yes! he would go to this lecture, it might be just what he needed.

"*All this Hollywood stuff!*"

He arrived at the big university lecture room after the lecture had already begun. The room was full of students, mostly young, listening with great attention to the tall, white-bearded man near the blackboard. When he entered, the professor was just busy writing a horrible-looking mathematical formula on the blackboard, something like this: $R_{\mu\nu}-\frac{1}{2}g_{\mu\nu}R=\kappa T_{\mu\nu}$.

Mr Tompkins's mathematical knowledge was limited to the four fundamental operations of arithmetic (of which he was using only the first two in his bank work), and the meaning of this funny-looking formula remained mysterious to him. He vaguely hoped that after covering all the blackboard with formulae, still more complicated than the first one, the professor would finally start to speak about some more understandable questions and would give a picture of the universe that he probably had in his mind.

This, however, was not the case, and, apart from the often-repeated sentence, "*the space in which we live is curved, closed in itself and in addition expanding*", Mr Tompkins could not learn anything that made any sense to him. It was not that this often-repeated sentence was much clearer to him than the rest of the lecture, but it made a deep impression on his mind. On the way home he tried to imagine the curved space, but could not go any further than thinking about it as something that looked like the bent fender on his old Ford.... No, he should not have gone to this lecture; the highlights of Science were not for him. In this state of mental depression he undressed and pulled the blanket over his head.

* * * *

Mr Tompkins awoke with the strange feeling of lying on something hard. He opened his eyes and found himself prostrated on what he first thought to be a big rock on the seashore. Later he discovered that it was actually a very big rock, about 30 feet in diameter, suspended in space without any visible support. The rock was covered with some green moss, and in a few places little bushes were

growing from cracks in the stone. The space around the rock was illuminated by some glimmering light and was very dusty. In fact, there was more dust in the air than he had ever seen, even in the films representing dust storms in the middle west. He tied his handkerchief round his nose and felt, after this, considerably relieved. But there were more dangerous things than the dust in the surrounding space. Very often stones of the size of his head and larger were swirling through the space near his rock, occasionally hitting it with a strange dull sound of impact. He noticed also one or two rocks of approximately the same size as his own, floating through space at some distance away. All this time, inspecting his surroundings, he was clinging hard to some protruding edges of his rock in constant fear of falling off, and being lost in the dusty depths below. Soon, however, he became bolder, and made an attempt to crawl to the edge of his rock and to see whether there was really nothing underneath, supporting it. As he was crawling in this way, he noticed, to his great surprise, that he did not fall off, but that his weight was constantly pressing him to the surface of the rock, although he covered already more than a quarter of its circumference. Looking from behind a ridge of loose stones on the spot just underneath the place where he originally found himself, he discovered nothing to support the rock in space. To his great surprise, however, the glimmering light revealed the tall figure of a man with a long white beard, standing apparently with his head down and making some notes in his pocket-book. He recognized the professor whose lecture he had attended in the evening.

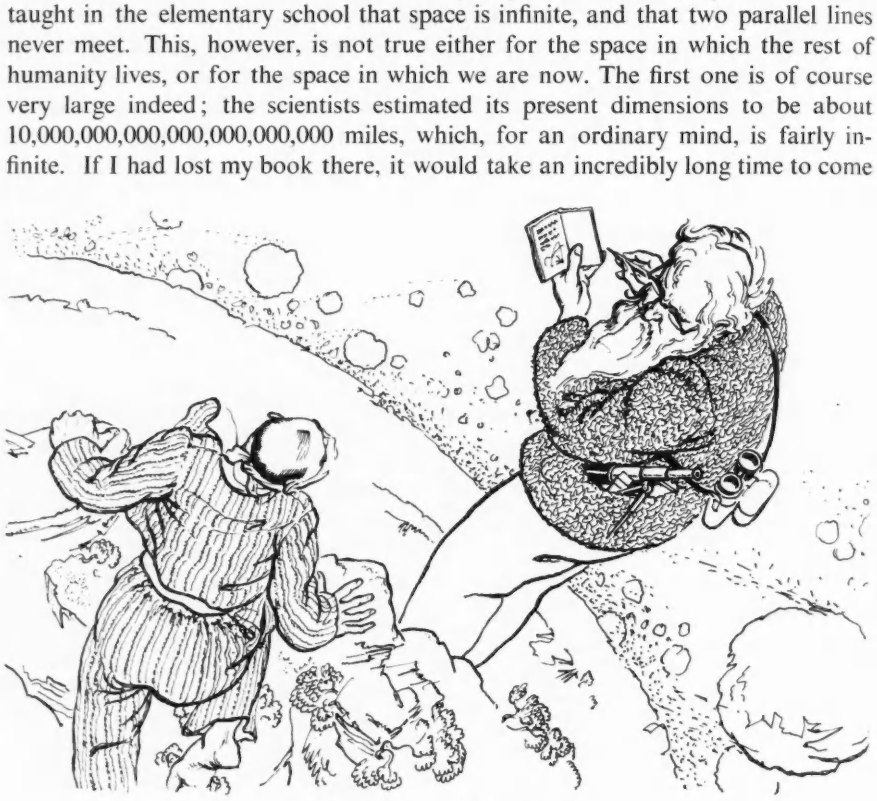
Now Mr Tompkins began slowly to understand. He remembered that he was taught in his schooldays that the earth is a big round rock moving freely in space around the sun. He also remembered the picture of two antipodes standing on the opposite sides of the earth. Yes, his rock was just a very small stellar body attracting everything to its surface, and he and the old professor were the only population of this little planet. This consoled him a little; there was at least no danger of falling off!

"Good morning," said Mr Tompkins, to divert the old man's attention from his calculations.

The professor raised his eyes from his note-book. "There are no mornings here," he said, "there is no sun and not a single luminous star in this universe. It is lucky that the bodies here show some chemical process on their surface, otherwise I should not be able to observe the expansion of this space", and he returned again to his note-book.

Mr Tompkins felt quite unhappy; to meet the only living person in the whole universe, and to find him so unsociable! Unexpectedly, one of the little meteorites came to his help; with a crashing sound the stone hit the book in the hands of the professor and threw it, travelling fast through space, away from their little planet. "Now you will never see it again", said Mr Tompkins as the book got smaller and smaller, flying through space.

"On the contrary", replied the professor. "You see, the space in which we now are is not infinite in its extension. Oh yes, yes, I know that you have been taught in the elementary school that space is infinite, and that two parallel lines never meet. This, however, is not true either for the space in which the rest of humanity lives, or for the space in which we are now. The first one is of course very large indeed; the scientists estimated its present dimensions to be about 10,000,000,000,000,000,000,000 miles, which, for an ordinary mind, is fairly infinite. If I had lost my book there, it would take an incredibly long time to come



"There are no mornings here"

back. Here, however, the situation is rather different. Just before the note-book was torn out of my hands, I had figured out that this space is only about five miles in diameter, though it is rapidly expanding. I expect the book back in not more than half an hour."

"But", ventured Mr Tompkins, "do you mean that your book is going to behave like the boomerang of an Australian native, and, by moving along a curved trajectory, fall down at your feet?"

"Nothing of the sort", answered the professor. "If you want to understand what really happens, think about an ancient Greek who did not know that the earth was a sphere. Suppose he has given somebody instructions to go always straight northwards. Imagine his astonishment when his runner finally returns to him from the south. Our ancient Greek did not have a notion about travelling

round the world, (round the earth, I mean in this case,) and he would be sure that his runner had lost his way and had taken a curved route which brought him back. In reality his man was going all the time along the straightest line one can draw on the surface of the earth, but he travelled round the world and thus came back from the opposite direction. The same thing is going to happen to my book, unless it is hit on its way by some other stone and thus deflected from the straight track. Here, take these binoculars, and see if you can still see it."

Mr Tompkins put the binoculars to his eyes, and, through the dust which somewhat obscured the whole picture, he managed to see the professor's note-book travelling through space far far away. He was somewhat surprised by the pink colouring of all the objects, including the book, at that distance.

"But", he exclaimed after a while, "your book is returning, I see it growing larger."

"No", said the professor, "it is still going away. The fact that you see it growing in size, as if it were coming back, is due to a peculiar focusing effect of the closed spherical space on the rays of light. Let us return to our ancient Greek. If the rays of light could be kept going all the time along the curved surface of the earth, let us say by refraction of the atmosphere, he would be able, using powerful binoculars, to see his runner all the time during the journey. If you look on the globe, you will see that the straightest lines on its surface, the meridians, first diverge from one pole, but, after passing the equator, begin to converge towards the opposite pole. If the rays of light travelled along the meridians, you, being for example, located on one pole, would see the person going away from you growing smaller and smaller only until he crossed the equator. After this point you would see him growing larger and it would seem to you that he was returning, going, however, backwards. After he had reached the opposite pole, you would see him as large as if he were standing right by your side. You would not be able, however, to touch him, just as you cannot touch the image in a spherical mirror. On this basis of two-dimensional analogy, you can imagine what happens to the light rays in the strangely curved three-dimensional space. Here, I think the image of the book is quite close now." In fact, dropping the binoculars, Mr Tompkins could see that the book was only a few yards away. It looked, however, very strange indeed! The contours were not sharp, but rather washed out, the formulae written by the professor on its pages could be hardly recognized, and the whole book looked like a photograph taken out of focus and underdeveloped.

"You see now", said the professor, "that this is only the image of the book, badly distorted by light travelling across one half of the universe. If you want to be quite sure of it, just notice how the stones behind the book can be seen through its pages."

Mr Tompkins tried to reach the book, but his hand passed through the image without any resistance.

"The book itself", said the professor, "is now very close to the opposite pole of

the universe, and what you see here are just two images of it. The second image is just behind you and when both images coincide, the real book will be exactly at the opposite pole." Mr Tompkins didn't hear; he was too deeply absorbed in his thoughts, trying to remember how the images of objects are formed in elementary optics by concave mirrors and lenses. When he finally gave it up, the two images were again receding in opposite directions.

"But what makes the space curved and produce all these funny effects?" he asked the professor.

"The presence of ponderable matter", was the answer. "When Newton discovered the law of gravity, he thought that it was just an ordinary force, the same type of force as, for example, is produced by an elastic string stretched between two bodies. There always remains, however, a mysterious fact that all bodies, independent of their weight and size, get the same acceleration and move the same way under the action of gravity, if you eliminate the friction of air and that sort of thing, of course. It was Einstein who first made it clear that the primary action of ponderable matter is to produce the curvature of space and that the trajectories of all bodies moving in the field of gravity are curved just because space itself is curved. But I think it is too hard for you to understand, without knowing sufficient mathematics."

"It is", said Mr Tompkins. "But tell me, if there were no matter, would we have the kind of geometry I was taught in school, and would parallel lines never meet?"

"They would not," answered the professor, "but neither would there be any material creature to check it."

"Well, perhaps Euclid never existed, and therefore could construct the geometry of absolutely empty space?"

But the professor apparently did not like to enter into this metaphysical discussion.

In the meantime the image of the book went off again far away in the original direction, and started coming back for the second time. Now it was still more damaged than before, and could hardly be recognized at all, which, according to the professor, was due to the fact that the light rays had travelled this time round the whole universe.

"If you turn your head once more," he said to Mr Tompkins, "you will see my book finally coming back after completing its journey round the world." He stretched his hand, caught the book, and pushed it into his pocket. "You see," he said, "there is so much dust and stone in this universe that it makes it almost impossible to see round the world. These shapeless shadows which you might notice around us are most probably the images of ourselves, and surrounding objects. They are, however, so much distorted by dust and irregularities of the curvature of space that I cannot even tell which is which."

"Does the same effect occur in the big universe in which we used to live before?" asked Mr Tompkins.

"Oh yes," was the answer, "but that universe is so big that it takes the light milliards of years to go round. You could have seen the hair cut on the back of your head without any mirror, but only milliards of years after you had been to the barber. Besides, most probably the interstellar dust would completely obscure the picture. By the way one English astronomer even supposed once, mostly as a joke, that some of the stars which can be seen in the sky at present are only the images of stars which existed long ago."

* * * *

Tired of all the efforts to understand all these explanations, Mr Tompkins looked around and noticed, to his great surprise, that the picture of the sky had considerably changed. There seemed to be less dust around, and he took off the handkerchief which was still tied round his face. The small stones were passing much less frequently and hitting the surface of their rock with much less energy. Finally, a few big rocks, like their own, which he had noticed in the very beginning, had gone much farther away and could hardly be seen at this distance.

"Well, life is certainly becoming more comfortable", thought Mr Tompkins, "I was always so scared that one of those travelling stones would hit me. Can you explain the change in our surroundings?" he said, turning to the professor.

"Very easily; our little universe is rapidly expanding and since we have been here its dimensions have increased from *five to about a hundred miles*. As soon as I found myself here, I noticed this expansion from the reddening of the distant objects."

"Well, I also see that everything is getting pink, at great distances," said Mr Tompkins, "but why does it signify expansion?"

"Have you ever noticed", said the professor, "that the whistle of an approaching train sounds very high, but after the train passes you, the tone is considerably lower? This is the so-called Doppler Effect: the dependence of the pitch on the velocity of the source. When the whole space is expanding, every object located in it moves away with a velocity proportional to its distance from the observer. Therefore, the light emitted by such objects is getting redder, which in optics corresponds to a lower pitch. The more distant the object is, the faster it moves and the redder it seems to us. In our good old universe, which is also expanding, this reddening, or the red-shift as we call it, permits astronomers to estimate the distances of the very remote clouds of stars. For example, one of the nearest clouds, the so-called Andromeda nebula, shows 0·05 % of reddening, which corresponds to the distance which can be covered by light in eight hundred thousand years. But there are also nebulae just on the limit of present telescopic power, which show a reddening of about 15 % corresponding to distances of several millions of light years. Presumably, these nebulae are located almost on the halfway point of the equator of the big universe, and the total volume of space which is known to terrestrial astronomers represents a considerable part

of the total volume of the big universe. The present rate of expansion is about 0·00000001 % per year, so that each second the radius of the universe increases by *ten million* miles. Our little universe grows comparatively much faster, gaining in its dimensions about 1 % per minute."

"Will this expansion never stop?" asked Mr Tompkins.

"Of course it will", said the professor. "And then the contraction will start. Each universe pulsates between a very small and a very large radius. For the big universe the period is rather large, something like several thousand million years, but our little one has a period of only about two hours. I think we are now observing the state of largest expansion. Do you notice how cold it is?"

In fact, the thermal radiation filling up the universe, and now distributed over a very large volume, was giving only very little heat to their little planet, and the temperature was at about freezing-point.

"It is lucky for us", said the professor, "that there was originally enough radiation to give some heat even at this stage of expansion. Otherwise it might become so cold that the air around our rock would condense into liquid and we would freeze to death. But the contraction has already begun, and it will soon be warm again."

Looking at the sky, Mr Tompkins noticed that all distant objects changed their colour from pink to violet which, according to the professor, was due to the fact that all the stellar bodies had started moving towards them. He also remembered the analogy given by the professor of the high pitch of the whistle of an approaching train, and shuddered from fear.

"If everything is contracting now, shouldn't we expect that soon all the big rocks filling the universe will come together and that we shall be crushed between them?" he asked the professor anxiously.

"Exactly so," answered the professor calmly, "but I think that even before this the temperature will rise so high that we both will be dissociated into separate atoms. This is a miniature picture of the end of the big universe—everything will be mixed up into a uniform hot gas sphere, and only with a new expansion will new life begin again."

"Oh my!" muttered Mr Tompkins—"In the big universe we have, as you mentioned, milliards of years before the end, but here it is going too fast for me! I feel hot already, even in my pyjamas."

"Better not take them off," said the professor, "it will not help. Just lie down and observe as long as you can."

Mr Tompkins did not answer; the hot air was unbearable. The dust, which became very dense now, was accumulating around him, and he felt as if he were being rolled up in a soft warm blanket. He made a motion to free himself, and his hand came out into cool air.

"Did I make a hole in that inhospitable universe?" was his first thought. He wanted to ask the professor about it, but could not find him anywhere. Instead,

in the dim light of the morning, he recognized the contours of the familiar bedroom furniture. He was lying in his bed tightly rolled up in a woollen blanket, and had just managed to free one hand from it.

"New life begins with expansion", he thought, remembering the words of the old professor. "Thank God we are still expanding!"

And he went to take his morning bath.

Notes of the Month

Mathematics of Air Raid Protection

IN a letter to *Nature* on 29 October Professor Haldane gives an interesting mathematical treatment of Air Raid Protection. As he says, "In view of the discussion which is occurring on this subject, it seems desirable to have some quantitative measure of the degree of protection afforded by a given shelter. In order to limit the problem we may consider only risks of death, and further confine ourselves to high explosive bombs. Incendiaries have proved a negligible danger to life in Spain, and gas is also negligible except for babies and those whose respirators do not fit."

Some of his conclusions are:

1. The rather obvious one that a policy of dispersing a population *within* a dangerous area does not reduce the probable number of casualties; that is, a population evenly spread over London will suffer to the same extent as one gathered into large populated knots, leaving empty spaces elsewhere within the area. "It merely ensures that no single bomb will kill a large number of people, while increasing the probability that any given bomb will kill at least one. It is likely to save

a few lives by equalizing the numbers of wounded to be treated in different hospitals; and the psychological effect of having 20 killed in each of 10 areas may perhaps be less than that of 200 killed in one area."

2. A trench gives protection which is nearly complete if the bomb falls outside the trench, and is practically useless if it does not. In these cases it is apparent that the probability of getting killed depends mainly on the area of a straight section of trench, and is about seven times as great in a trench 70 ft. long by 6 ft. wide as in one 16 ft. long by 4 ft. wide.

3. "It would seem that, in the design of many shelters, too much stress has been placed on vertical protection, that is to say, protection from bombs falling immediately on the individual's protection, and not enough on horizontal protection; that is to say, protection from bombs falling at some distance from them."

4. As between trenches and concrete shelters, the calculations suggest that where heavy bombs are likely to be used the trench is to be preferred. On the other hand, if the concrete shelter were divided into a number of cells by stout walls, it would be safer than a trench.

A New Satellite of Jupiter

Satellite X of Jupiter has recently been discovered. It is known to be about 7,000,000 miles from the planet, and an argument is now proceeding about the shape of its orbit.

Since the data are scanty, two orbits can be calculated, each of which appears to be equally plausible. One makes Satellite X approach most closely to Jupiter at a distance of 2,150,000 miles, with a greatest distance of 9,650,000 miles. The second orbit suggests the nearest approach to be very much farther away, actually a distance of 6,945,000 miles, and the farthest distance to be 29,675,000 miles. With this large orbit, the time to complete a revolution would be nearly three years.

Neutrons and the Origin of Life

J. Tandberg of Stockholm has put forward an original speculation about the influence of neutrons on the origin of life.

"When in early days of the development of the earth its surface was covered with an aseptic solution of various organic compounds, these did not react in the same way as they would have done if certain enzymes, colloids and other complicated substances had already been present. The very first impetus to further development had to be given from molecules, containing, for example, carbon and nitrogen in certain combinations. One possible way of combining nitrogen and carbon, not yet discussed in this connection, may be found in conjunction with certain nuclear reactions, also prevalent in Nature at those early days.

By the action of cosmic rays or hard γ-rays from radioactive matter present in the ocean, the deuterium of the heavy water, contained in the ocean water, will produce neutrons. These neutrons are slowed down in the water and will react with the nuclei of atoms in the molecules dissolved in the water. Thus, for example, a heavy carbon atom in an already existent carbon chain compound should be transformable (through a short-lived radioactive carbon isotope) into a stable nitrogen atom by expulsion of a β-particle.

If the molecule in which this reaction takes place is not destroyed by the recoil or by the particle, the new nitrogen atom may give rise to a new, rather unexpected molecule containing a carbon-nitrogen link and capable of new reactions. In the same way also a phosphorus atom may be generated from a silicon atom and so on.

Even the direct action of very hard γ-rays on oxygen is capable of producing a stable nitrogen atom (with mass number 15) through a short-lived radioactive oxygen isotope.

Thus various complicated organic molecules containing, for example, carbon-nitrogen may have originated in a way rather different from ordinary chemical reactions and will perhaps have influenced the evolution of organic matter, eventually leading to the first primitive forms of living matter, no longer present on earth."

The Cyclotron

The Cyclotron is the most formidable machine which has been used in modern physical research. It was invented by E. O. Lawrence in the University of California, and is a most ingenious method for accelerating atomic particles to energies of millions of volts instead of a few hundred thousands. These enormous energies are necessary in order to disintegrate the nuclei of the heavier atoms. High as the cost of installation of a cyclotron is, it is so full of possibilities that two have been built in England, and are now nearly ready for use: one in Cambridge and the other in Liverpool; the second was built under the instructions of Professor Chadwick, the last English Nobel Prize winner for Physics.

With these machines it should be possible to reach energies of 10,000,000 volts for protons, and 15,000,000 volts for alpha particles. With such tremendous energies, it is probable that we shall soon know far more of the transmutations of the heavy nuclei.

The Prickly Pear Cactus

The curse of the prickly pear cactus in Australia is definitely coming under control, according to a report of the Council for Scientific and Industrial Research in that country. The benefits accruing from the destruction of the cactus by *Cactoblastis* are being realized. Large tracts of country are being improved for timber-growing, and towns and settlements in the pear country reflect the changed conditions by their renewed prosperity.

Recording the Dance and Song of the Lyre Bird

By Edward Samuel

MENURA, the Lyre Bird, is found only in Australia's most thickly vegetated country; near Melbourne in the Dandenong Ranges, and near Sydney in the Blue Mountains. It was first shown to Europeans in 1798 by a party of men who set out from Port Jackson in search of land. At first it was thought to be an Australian Bird of Paradise, and even until quite recently was known as "the native pheasant". The bird is dark brown, and about the size of the domestic fowl. It lives almost entirely on the ground, raking the forest floor continually in search of grubs, worms and beetles. Practically the only difference in the appearance of the sexes lies in the tail; that of the female is long, but commonplace, while that of the male is one of the most remarkable ornaments worn by any bird, its name being based on the resemblance of the tail feathers to the lyre. Certainly, when the tail has been removed, the two large feathers, each over two feet long, and the twelve filmy plumes of the same length, may be arranged

Male lyre bird with tail raised in the first stage of display

The tail of the male bird is upright in the early stage of the dance. The beak is wide open

in the lyre pattern, although in life the lyre shape is seldom apparent. Conscious, apparently, of the beauty of its tail, the male bird performs a remarkable "dance" on little patches cleared for the purpose. The beauty of the tail is then wonderfully displayed. It is a thrilling sight, and the more exciting on account of the difficulties incurred in witnessing it. During the display, and at other times as well, the bird sings so loudly that it may be heard a quarter of a mile away. It is an accomplished mimic, too, and many of the items in its song are exact reproductions of the songs of other birds, while other items are semi-original, being based on the sounds heard about it. But it is a singer in its own right as well, and many of the beautiful notes are entirely original. The male lyre bird is a great artist, but a poor helpmate. He takes no part in the domestic work, and the one egg which is laid each year is incubated by the female who feeds the chick without any assistance. The bird is strictly protected by law but, during recent years, the species has become such a general favourite that protective laws are scarcely necessary.

The tail is reversed over the back, and the silvery white underside is displayed

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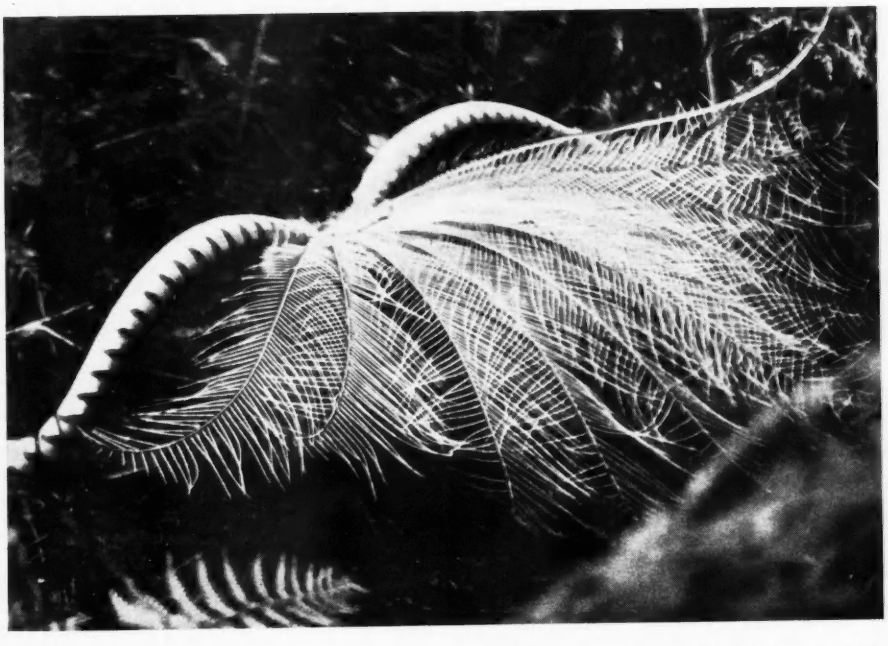
The female lyre bird



The male bird in a typical display attitude

Mr Tregallas, a veteran naturalist, did much to bring the charm of this natural artist to the notice of the world. He delivered a series of entertaining lectures, spreading abroad the knowledge he had acquired about it after many years of study.

The male bird raking the surface of a dancing mound

It was one of these lectures which inspired Mr Littlejohn of Melbourne to record for the screen the life-story of this largest of all song birds, and to capture the song for reproduction overseas. He devoted fourteen years to the attainment of this ambition, and was responsible for the taking of two motion pictures for association with direct broadcasts and recordings accomplished under natural conditions. The first film took seven years to make, while the film just released by the Australian Government has taken three. Both were photographed at Sherbrooke Forest, 25 miles from Melbourne, but the later film is much more efficient than the earlier one. This is partly due to the improvements made in negative films in recent years, and partly to a greater knowledge of the habits of individual birds gained by longer association with them.

Besides being a creature of the shadows, the lyre bird chooses to sing and dance in the depth of winter, when the forest, naturally dull, is shrouded almost continually in cloud and fog, and when it is most difficult to get a clear and uninterrupted view of the singer. Two whole seasons were devoted to that portion of the latest picture which, in three minutes on the screen, depicts the dance of the male lyre bird performed on small circular patches or mounds.

Some idea of the extreme caution of the species is given by an experience during the early stages of the taking of this new film. At this time the camera was used in a padded box, which was camouflaged among ferns 15 feet from a mound, and operated from a considerable distance by means of a line. During several weeks the bird refused to display on this mound, although it was clear that it had used it at other times. Eventually it was realized that the small shining lens, less than an inch in diameter, which was deeply recessed in the box, was the cause of the trouble, and a small cover was then made for it, and kept on until the motor was actually started. This device was successful at once, and several efficient shots were made by operating the camera with a line from 50 yards' distance. In order to speed up

A dancing mound in Sherbrooke Forest, Australia

The nest of the lyre bird, with a chick about five weeks old

operations, the camera was later carried in the hand so that exposures could be made at any mound instead of at only one. In a few instances, including the final scene in the picture, exposures were made from 10 feet. These shots are evidence of remarkable good fortune, for on hundreds of other occasions the bird refused to be photographed from any such distance. Long association with the particular bird, however, certainly did enable the photographer to forecast its movements and reactions with some degree of accuracy.

Filming the female bird was not so complicated, as the hen at nesting time is as trustful as one could wish. The dullness of the light was the main difficulty, however, and the operator may well be proud of a section of the picture which actually shows the mother feeding the chick in the nest while the camera whirred only 18 inches from

her. It took three weeks of tedious education with an electric buzzer before the noisy camera could be used at such close range.

The recording of the song which accompanies the dancing of the male bird was also made under natural conditions, but in somewhat easier circumstances, as the microphone will function when completely hidden, and makes no noise. The sound recording was made from the forest during a direct broadcast to radio listeners in every State in Australia. Broadcasts of this nature were made annually by the Australian Broadcasting Commission, the photographer's job on these occasions being to determine, by long observation of two male birds, the best positions for the microphone. A temporary studio was set up at a point between the two hidden microphones, and here a small group of technicians and officials waited all day in fog and cold for one or other of the chosen performers to sing near his own special microphone.

The Confidence Drug

By John Yudkin

WE have heard a great deal during the last year or two of a new drug, benzedrine. It has attained an immense degree of notoriety in the daily Press, where its unusual properties of stimulation have earned for it the name of "the confidence drug". The same Press, having encouraged and broadcast —to an extent which has led to its use by thousands of tired business men, anxious students and bored housewives—these remarkable claims of the drug's power to eliminate depression and increase intelligence, then clamoured for the legislative restriction of its sale. Just recently, such legislation has, in fact, been introduced. The drug is now on the list of scheduled poisons, and can only be obtained with a doctor's prescription.

What is the truth about this drug? How far are the popular views regarding its action justified? Is a person of ordinary or subnormal intelligence, for example, likely to be able to pass an academic examination through the effects of the drug, which otherwise he would certainly be unable to do? Is an individual, whose financial and family affairs have become unbearably difficult, going to be lifted from his state of extreme depression and so be much less likely to end his own life? And if the drug does *not* possess such properties, has it any value at all in medicine, and if so, in what conditions and to what degree? It is in order to answer such questions as these that I have attempted to bring together some of the undoubted and proven actions of this new substance.

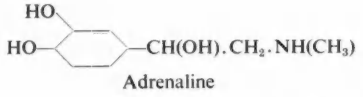
The discovery of the drug was the result of a search for chemical compounds which would have an action similar to that of adrenaline, but without the disadvantages associated with the use of this hormone. Adrenaline is a substance normally produced by two small glands, the adrenals, situated on the kidneys. It is secreted during periods of stress and emotion, in response to "fright, fight or flight". So that if you are suddenly confronted at night in a dark lane by someone demanding your gold watch and note case, your first reaction is one of fright. Whether your further reactions are those of fight or flight depends largely on the relative sizes of yourself and your opponent. In all of these conditions, adrenaline is poured into the blood stream, and its effect is to render the body more capable of meeting such emergencies. Thus, the circulation of blood in the muscles of the limbs is improved, both by an increase in the heart rate and by the closing down of many of the blood vessels of such easily dispersable areas as the digestive tract. At the same time, the whole process of digestion is slowed down by a decrease in the movement of the digestive apparatus, and by a closure of the numerous valves which shut off one portion of the tract from another. The effort of breathing is made easier by a dilatation of the air passages. There is also a rise in the sugar of the blood, so that more is available as an energy source for the activity of the body.

It is frequently useful to be able to obtain these effects in the treatment of various maladies. For example, adrenaline gives rapid and enormous relief in an attack of asthma, by virtue of its action of dilating the air passages. Its most dramatic use is seen when it is injected into the circulation or even directly into the heart, when this has ceased beating, for example, under an anaesthetic. Many persons have literally been brought back to life by the restoration of the circulation in this way. In conditions such as these, where an immediate response is desired, adrenaline is an immensely useful substance. But when a prolonged effect is desired, adrenaline is of no value. Moreover, it has no action when taken by mouth, since it is destroyed in the stomach. It has, therefore, to be injected, and this naturally limits its usefulness.

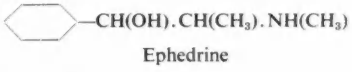
Apart from these general actions, adrenaline has an important local action in constricting the blood vessels. It is used in this way as a spray to relieve congestion in nasal catarrh or an attack of hay fever.

A valuable drug of the adrenaline type was found in ephedrine, isolated from a Chinese seaweed. It can be taken by mouth, and produces its effect in about half an hour. It has also been used as a spray in a similar way to adrenaline, and here, too, its action is slower, but more prolonged than this substance.

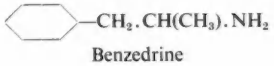
Adrenaline and ephedrine are related chemically, and can be synthesized in the laboratory. An enormous number of substances of similar chemical constitution have been synthesized and tested for their local and general effects.



Adrenaline



Ephedrine



Benzedrine

In 1930 a new substance was reported with the name beta-phenylisopropylamine, more generally known by its trade name, benzedrine. Its effects on animals were first studied. Then in 1932 there began to appear reports of its action when used as an inhalant in men and, lastly, from 1935 onwards, a great deal of work has been done on its effect on humans when taken by mouth.

Used locally, the new drug showed several distinct advantages over both adrenaline and ephedrine. These latter substances are not volatile, and have to be introduced into the nasal passages by spraying. Although modern sprays are very effective in the dispersal of a liquid, the intricacy of the nasal passages prevents their complete penetration by the sprayed fluid and the drug which it contains. Benzedrine, however, is volatile, so that when breathed into the nostril it can pass to all parts of the lining membranes of the nose and throat. It was found, too, that benzedrine has a second advantage. The constriction of the blood vessels, which results in the relief of the congestion, is followed, when adrenaline or ephedrine is used, by a reactionary

dilatation of these vessels. The relief obtained is, therefore, only temporary, and often the final condition of the nasal passages is worse than the original. This reaction is not found when benzedrine is used, so that the relief experienced from its use is more lasting. Some conditions for which inhalations of benzedrine have been successfully used are the common cold, infections of the sinuses and attacks of hay fever and asthma.

When taken internally, the drug has a variety of effects. It is the effect on the nervous system and brain which has been so much discussed recently, but let us first consider briefly the action of benzedrine on other systems. Like adrenaline and ephedrine, benzedrine causes a rise of blood pressure which is more prolonged than with these older drugs. It has, therefore, been given, with marked success, to patients with low blood pressure, who are subject to fainting attacks. The rise of blood pressure which benzedrine produces has the disadvantage that it renders the drug unsuitable for patients, who, for conditions such as those described later, would be given the drug, but have a dangerously high blood pressure already.

In many individuals benzedrine produces a loss of weight, and some doctors have used it in the treatment of obesity. Its inconsistent action, and the many unpleasant effects which, as we shall see, may accompany its use, have precluded its wide application for this condition.

* * * *

Another interesting use of the drug is in certain cases of sea-sickness. It appears that certain people are subject to sea-sickness because of the excessive activity of one part of their involuntary nervous system, the parasympathetic. Adrenaline stimulates the opposing nervous system, the sympathetic, so that adrenaline and drugs with a similar action are able to counteract the too energetic parasympathetic system in such individuals. The use of benzedrine has accordingly been attempted in the treatment of sea-sickness in these cases, and the results have been very promising.

The action on the brain and nervous system is one of stimulation. It produces a sensation of increased well-being and a relief from fatigue. There is a feeling of increased mental and physical energy, and the individual often describes himself as "full of pep". These facts led to the use of benzedrine in conditions of fatigue, sleepiness and depression, and in many cases there was seen a striking improvement. Some of the best results were seen in the treatment of narcolepsy, a disease in which the patient may have attacks either of irresistible sleep, or of suddenly losing the use of his limbs and falling limply to the ground. In most cases these attacks ceased entirely when benzedrine was taken—patients who were having as many as eight or ten attacks of falling asleep in one day were completely cured. Previously ephedrine has been used with moderately good results, but the effect of this drug gradually became less so that, after a few weeks, ephedrine had no effect. Benzedrine,

on the other hand, retained its original efficacy after being used continually for more than a year.

A second type of case for which the stimulating effect of benzedrine has been used is in that most distressing disease known as "post-encephalitic Parkinsonism". Some years after an attack of encephalitis lethargica, or sleepy sickness, which may have been so slight as not to have been diagnosed as this condition, some 10 or 20% of those attacked begin to develop Parkinsonism, or the "shaking palsy". The victim of this disease, often a young adult, presents a pathetic picture—rigid, bent body and legs, shuffling gait, shaking arms held across the front of his chest and features whose mournful expression is accentuated by a half-open mouth. Although nothing is yet known which can cure this disease, considerable relief can be achieved through the use of benzedrine. There is a decrease in the tremor and rigidity, and a marked improvement in the general well-being and strength of the patient.

It is in the less well-defined conditions of chronic fatigue and depression that it is so difficult to assess accurately the value of the drug. It is certainly true that in the states of pathological depression sometimes found in the truly mentally ill patient—the psychopathic or psychoneurotic—remarkable improvements often result from the use of benzedrine. In these cases the state of depression differs from that which we all may occasionally experience as the result of difficult or unpleasant circumstances, for they are characterized by the almost invariable absence of such precipitating causes. In fact, such pathological depression is curiously unaffected by unpleasant events which would cause considerable worry in normal individuals. In such patients, particularly when they are mildly affected, benzedrine can cause a wonderful lightening of their harassed minds.

* * * *

Further, improvement is often seen in cases of mental exhaustion where there is a lack of energy, a continuous sense of fatigue and an inability to concentrate—in fact, the symptoms of that mythical condition of "night starvation". In many of these cases, however, the improvement is only of a temporary nature.

In normal people, the general effects of benzedrine are also those of stimulation, as we have already shortly noted. There is a feeling of increased confidence and exhilaration, thought processes are accelerated and the individual becomes restless and talkative. The total effects may be highly gratifying, as during an interview where fluent talking, quick thinking and a confident manner produce an excellent impression. On the other hand, the effects may be disconcerting: a junior official in a hospital was severely taken to task for his jovial manner and loquaciousness when speaking on the telephone to a superior officer.

Intelligence tests, worked out by psychologists, have shown an increased score achieved by persons after taking benzedrine. As a well-known London physician has written: "The Press, unable to discriminate between intelligence testing and intelligence, spread the glad news of the discovery of a substance which among

other effects produced an increase of intelligence. Our 'Bright Young Things', and even more seriously minded people like students of medicine, began to take benzedrine in the hope that their chatter might be brighter or their examiners less formidable." Now there is no doubt that the effects we have described above are real, and that most people taking benzedrine feel brighter and more "alive". With regard to the intelligence tests, however, we must realize that the improved performance of laboratory trials is not really the result of an increase of native intelligence but rather the result of increased rapidity of thought. Much the same effect is seen after taking caffeine, and this accounts for the extensive popularity of drinks like tea and coffee which contain this substance. It is certain that no fundamental alteration in intelligence occurs, such as would make an individual capable of performances otherwise completely beyond his power.

The effects of benzedrine which we have so far described are desirable ones, and it was early seen that there was a possibility of persons becoming addicted to the use of the new drug. Surprisingly, however, in view of its stimulant actions, and disappointingly so far as the outcry in the Press is concerned, there have been very few reports indeed of benzedrine addiction.

There are two important reasons for this. In the first place it is found that although the effects are lasting in certain respects, such as in the improvement noted in Parkinsonism, the general stimulating effect on the normal individual appears to be lost after a few weeks or months. Secondly, and more important, the results of taking the drug are not entirely beneficial, for there are many unpleasant side effects. Its action in combating sleepiness, so useful in treating the condition of narcolepsy, may result in normal individuals in severe insomnia. The quickened thought and increase in energy may readily become, in certain individuals, unpleasant restlessness and irritability. Palpitations and headaches are not uncommon, and often there is uncomfortable flushing and perspiration. In a very few cases severer symptoms may occur, such as vomiting and collapse, but this is usually due to excessively large doses of the drug.

On the whole, then, we may consider that the danger from addiction is not very great. The restriction of the sale of benzedrine, however, which has recently been introduced, is justified by the fact that, although extremely valuable in certain conditions under medical supervision, it is a drug with very varied actions and often with many unpleasant results.

Lastly, one may ask whether the inhalation of benzedrine for the conditions we described earlier, may not produce the more widespread general effects seen after taking the drug by mouth. Experiments have recently been performed in which it has been found that the amount of benzedrine which can be inhaled is very much less than that required to produce any general stimulation. So that the alarming picture which has been drawn by the fanatical clamourers for the restriction of the sale of the drug, of a benzedrine addict secretly sniffing at his inhaler, is an extremely unlikely one to be met with in real life.

Some Problems of Modern Street Lighting

By R. C. Evans

LIGHTING IN EARLY TIMES

Artificial illumination has been known to man from the time when he first discovered the use of fire and, although his fire was doubtless originally prized primarily for its heat, he soon came to appreciate no less the social value of the light which it shed, so that, first as a flaming faggot from the fire, and later as the torch and the oil lamp, we find deliberate attempts to develop and improve artificial light sources. As early as 3500 B.C. lamps burning vegetable or animal oils were in use in Ur of the Chaldees, while in the first century A.D. Pliny describes the precursor of the candle—a primitive rush-light formed by soaking the pith of a rush in oil or fat. In the fourth century the candle of bleached wax was introduced by the Phoenicians, and in the succeeding centuries oil lamps underwent modification in detail and often developed into objects of very great beauty, such as that shown in Fig. 2. But apart from the discovery of new and more suitable types of oil, which gave a cleaner and less obnoxious flame, little improvement was effected. It was not until 1784 that the use of a glass chimney was introduced to improve the draught, and only in 1843 that mineral oils replaced those of animal or vegetable origin.

In spite of the existence of lamps of quite

passable efficiency from Roman times onwards, it seems to have been many centuries before any attempt was made to provide illumination outside the confines of the home or temple. It is true that in Antioch a system of street lighting existed in the fourth century A.D., and that in public places in other cities open fires in large iron baskets were kept burning, but it is probable that in the latter case their purpose was symbolical rather than utilitarian.

In England, at any rate, it was in 1417 that street lighting first appeared, for in that year the Lord Mayor of London ordained "lanthorns with lights to bee hanged out on the winter evenings betwixt Hallowtide and Candlemasse". Street lighting thus became the responsibility of the individual householder, and for over three centuries this system remained in force. The arrangement appears to have been much resented, for we read of the great difficulty in enforcing the decree, while at the same time the resultant illumination was quite inadequate, and it remained necessary for the nocturnal traveller to be accompanied by his "link-boy" carrying a torch, or link, to light his path. The resentment may indeed have been well founded, for at the time even the most meagre illumination was very costly, so much so in fact that we still symbolize as "burning the candle at both ends" any display of wanton or reckless extravagance. By the

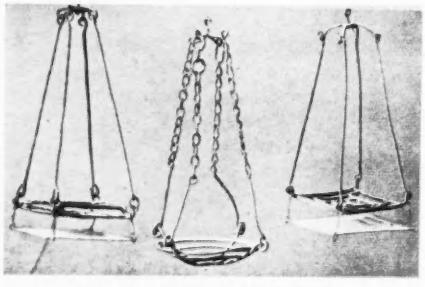


Fig. 1. Primitive fire baskets

beginning of the eighteenth century the position became acute. Householders refused to comply with the decree of 1417 and, as a result of their neglect, "when night darkened the streets there wandered forth the sons of Belial, flown with insolence and wine", while robbery and other lawlessness became common. In 1736 the responsibility of street lighting was finally removed from the individual and became a charge on the rates. Within two years there were fifteen thousand street lights in London alone, and by 1770 oil lamps mounted on columns were to be found in every important street. They appear as a conspicuous feature in contemporary pictures, and in Hogarth's engraving, *The Rake's Progress IV* (see p. 455), a lamplighter is clearly shown refilling a standard oil lamp. Early in the nineteenth century the development of gas lighting led to further advances, and in 1809 it was used for the first time for street illumination

Fig. 2. Early multiple wick open flame oil lamp

in Pall Mall. Progress thereafter was rapid, stimulated still further by the invention of the arc light and, later, of the metal filament electric lamp.

In spite of all the advances just described in the sources of light available, there was until a few years ago no corresponding advance in the proper application of these methods of illumination. Lamps were designed solely on aesthetic grounds without any consideration of their functional purpose, so that the street lights of even a decade ago were little different, except in the source of light, from those set up when street lighting first became a public responsibility in the reign of George II. Only in the last ten years has any systematic attempt been made to study scientifically the problems involved in the proper illumination of a thoroughfare in a manner adequate for modern requirements.

(*Science Museum, South Kensington*)

Fig. 3. *Pall Mall in* 1809, *the first gas-lit street in London*

We can never hope to emulate by night the conditions of illumination which we obtain by day. In bright sunshine the intensity of illumination may exceed 10,000 foot-candles,* and even on a dull day reaches 700 foot-candles or more, but only in the most brilliantly lighted streets is the illumination by night as high as 0·2 foot-candles. There is, therefore, a factor of at least 3500 between conditions by day and by night, and it is clear that any attempt to approach daylight conditions in street lighting would be altogether prohibitive in cost. The very low intensities to which the lighting engineer must necessarily reconcile himself introduce a number of particular problems not encountered in other branches of illuminating engineering.

For the slow-moving pedestrian, who requires little more than sufficient light to enable him to discern the kerb and the trees or other objects in his path, the level of illumination provided generally ten years ago, and still provided to-day on all but our main thoroughfares, is doubtless sufficient, but for traffic requirements it is entirely inadequate. Sufficient lighting is achieved only when motor traffic can proceed with no more delay than by day and without the use of headlamps and without imposing any undue nervous or physical strain on the driver. The driver must, therefore, be able to discern objects on the road as quickly and clearly by night as by day.

THE SILHOUETTE EFFECT

In bright light objects are recognized both by contrasts of colour and by contrasts of

* The foot-candle may be roughly defined as the intensity of illumination at a distance of one foot from a candle.

brightness. A body may stand out from its background because it is differently coloured or because it is brighter or less bright than that background. At very low light intensities, however, the eye loses its colour sense and a discrimination of objects by their colour alone becomes difficult or impossible. The reader can readily confirm this for himself by trying to sort in a very dim light a number of objects (say, some threads of wool or some brightly coloured books) similar in shape but different in colour. In street lighting it is consequently necessary to rely solely on differences of brightness for discrimination, and since the majority of objects to be found on a road are dark in colour this can only be achieved if these objects appear in silhouette against a bright background. The clear visibility of objects seen under these conditions is shown in Fig. 4.

(*From* Light and Lighting)

Fig. 4. *The silhouette effect, showing the clear visibility of dark figures seen against a brightly lit road surface*

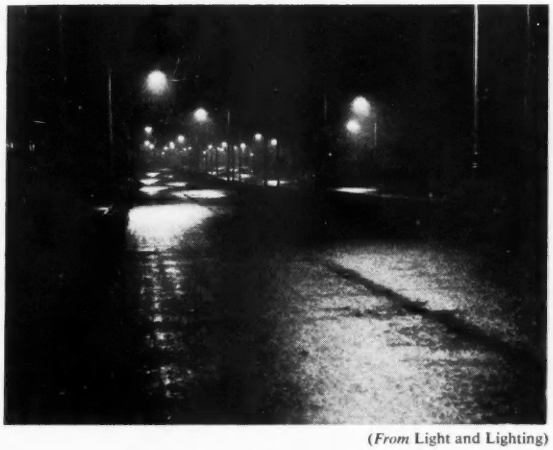
From the above considerations it is clear that the primary requirement of a well-lighted street is a brightly and uniformly illuminated road surface. Each separate lamp produces a pool of illumination on the road situated between the lamp and the observer. In order that these pools may merge into one another and cover the whole area of the road surface, the lamps must be carefully placed not too far apart and must overhang the roadway. Except in very narrow streets, alternate lamps must be staggered. In practice, lamps not more than 125 feet apart and at a height of 25 feet are satisfactory on a straight road.

The illumination of the road surface rather than of the objects on it necessitates that lamps should be designed to direct the greater part of their light along the highway and at an angle very little below the horizontal, since the light reaches the driver's eye by more or less specular reflection at small angles from the road surface. This condition unfortunately means that unavoidably some light also reaches his eye direct from the lamp, and if this is too bright unpleasant glare and dazzle result. The individual lights should therefore not be too bright, and the best results are obtained when a large number of relatively dim lamps is employed.

THE ROAD SURFACE

Since the road is illuminated primarily by the light reflected from its surface, the nature of this surface itself plays an important part in a successful lighting scheme, and this factor must always be taken into account in road surfacing. A very rough matt surface scatters light diffusely, so that in any one direction it reflects only very little light and appears dark, while a very highly polished surface behaves too nearly like a perfect mirror and presents the appearance of a series of discrete bright reflections of the separate lamps on an otherwise dark field. Some condition intermediate between these extremes is desirable, and it is interesting to note in this connexion that it is the sheen rather than the colour of the surface which is of importance—at very oblique incidence

light is reflected equally well from surfaces of almost any colour. The conditions are, of course, entirely different in country roads designed to be lighted only by the lights of the traffic on them. Here the road surface is seen by the light scattered backwards, as opposed to that reflected forwards, and the lightest possible surface is desirable for good visibility.



(*From* Light and Lighting)

Fig. 5. A badly lit road, showing patchy appearance due to widely spaced lamps

The effect of too widely spaced lamps or of a too highly polished road surface is shown in Fig. 5. Beside the danger of objects in the dark patches remaining unseen, such a wide and repeated variation in intensity is particularly fatiguing to the eye, which is forced continually to accommodate itself to the changing conditions. The reader can easily demonstrate to himself the extent of this discomfort by attempting to read in a well-lighted room where the illumination on his book is supplemented by a local source, such as a table lamp, which is repeatedly switched on and off at short intervals. Such fatigue is further dangerous in that it may ultimately lead to an unconscious repression of reactions to stimuli, and so to a general relaxation of attention and a lowering of the standard of driving on the road. The proper arrangement of street lamps to provide adequate illumination has recently been considered by a Ministry of Transport committee which has drawn up recommendations embodying the minimum requirements for streets of various classes, including such exceptional conditions as those associated with sharply curved roads, one-way streets and roundabouts. These recommendations are normally adopted in all new street lighting schemes.

THE LIGHT SOURCE

The advances in street lighting which have resulted in the last ten years from a scientific approach to the problems of the proper arrangement of the lighting units have also been accompanied by corresponding advances in the source of light itself. Ten years ago the incandescent light, either of gas or electricity, was the only practicable source of illumination, but recent developments of the electric discharge lamp have provided a new source of great promise, and with many advantages. These lamps are capable of converting into light a very much greater fraction of the total energy consumed than is possible with the filament lamp, so that their efficiency is several times that of a source of the latter type and the cost of operation correspondingly less. They do, moreover, possess the further advantage that the luminous source can be of considerable size, so that a high total intensity can be achieved without the high brightness that produces the unpleasant sensation of glare.

The chief disadvantage of such lamps, which makes them unsuitable for many purposes, is that their light is not white but either monochromatic or composed of only a few isolated colours, the most familiar being the yellow of sodium, the red of neon and the bluish green of mercury. The colour-rendering power of these sources is therefore entirely false, but we have already seen that

in the low intensities of illumination encountered on even the best lighted roads, such a disability is of little consequence, since in any case the eye itself is almost wholly insensitive to colour values, and it is only by a silhouette effect that objects can be recognized.

Gas lamps, incandescent electric lights and discharge lamps are all to be found in recent installations in this country, and yet it is difficult to believe that in each case the particular system chosen is that best suited to its purpose, or to escape the conclusion that in many cases the choice between them is determined either by ignorance or by private interests. Even if there is little to choose between such systems at the present time, there can be little doubt in which direction future developments will take place, and only by judicious selection at the outset can the danger of heavy replacement costs, necessitated by further progress in the future, be avoided. It is unfortunate that the Ministry of Transport committee does not give specific guidance in this matter.

(General Electric Co.)

Fig. 6. A well-lit street

LIGHTING IN THE FUTURE

The rapid development in scientific street lighting in the last few years gives every reason to believe that progress in the near future will be no less considerable, but it does at the same time bring with it corresponding dangers. Few local authorities have engineers adequately versed in lighting problems, and in a well-intentioned desire to provide improved conditions have sometimes hastily adopted ill-considered schemes either needlessly costly or technically unsuitable.

Early Microphotography and the Paris Post of 1870

By R. E. D. Clark

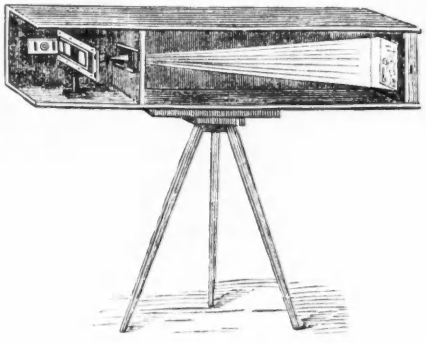
(The cuts in this article are taken from the British Journal of Photography, *and show early apparatus for the making of microphotographs)*

The microphotography of documents is being much talked about at the present time. Not many weeks pass without some noted librarian declaring that the photographic reproduction of printed matter on a greatly reduced scale will eventually solve the problems of the modern library. At the present moment all the early printed books in the British Museum are being copied on film, while some forty American newspapers arrange for filmed copies of their pages to be made available in the American libraries. In addition, thousands of pages of old newspaper files have been reproduced on film, while the Banks have for long copied every cheque which passes through their clearing houses. In America many early books long since out of print have now been published in the form of rolls of film. A large quantity of sociological research material has been copied, the original of which was in part lost for good in the great Mississippi floods. And so the microphotography of documents proves to have more far-reaching uses as every year passes by, and Mr H. G. Wells's speculations on its place in the world of the future seem less and less fantastic. It looks as if the world is just awakening to the possibilities of a development, the only past parallel of which was the invention of printing itself.

It is of some interest to turn from these new applications of microphotography to its early history—for the idea is not really new, but dates right back to the earliest days of photography and it even found practical application many years ago.

The first microphotographs were produced by the Daguerreotype method as early as 1840. Before 1860 they were being produced in great numbers by the now obsolete collodion process, particularly by amateur photographers. In the *Photographic News* for 1859 and 1860 various suggestions for the use of such photographs were put forward. It was suggested that they would be very useful to spies in war time, who might thus carry large numbers of documents about their person in such a minute form that there would be little fear of discovery even after careful searching. There was, for instance, scarcely a limit to the quantity of material which could be carried in a single button or in the ornamental top of a pencil.

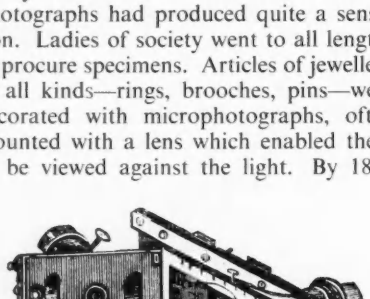
Then again it might happen in war time that two armies would become separated and unable to send secret messages to one another. In such cases it was suggested that military documents should be copied



on film and placed inside a rifle bullet which, at an agreed signal, would swiftly carry its valuable messages over one or two miles of territory occupied, perhaps, by enemy troops. Finally, it was claimed that, if necessary, the entire archives of a nation could be made to fit neatly into a

snuff box, although at that time there did not seem any point in making them do so.

Although these suggestions were freely discussed they came to nothing and were soon forgotten. Microphotography, however, rapidly forged ahead, though it served no really useful purpose. Within a few years of their introduction the tiny photographs had produced quite a sensation. Ladies of society went to all lengths to procure specimens. Articles of jewellery of all kinds—rings, brooches, pins—were decorated with microphotographs, often mounted with a lens which enabled them to be viewed against the light. By 1864



pocket knives were being vended at a cost of only three shillings each, in which a tiny picture with a lens in front of it had been mounted in the axis of the knife. In the same year a respectable photographic magazine was deploring the use of such wares for the portrayal of undesirable pictures.

At about the same period microscope slides were on sale labelled "A Photographic Curiosity for the Microscope". These consisted of tiny pictures—often as small as a pin's head—of such subjects as "The Soldier's Dream", "Kilchurm Castle", "Prince Albert", "Eminent Men", and so on. Some of these slides were on view at the Exhibition of Apparatus for the Reproduction of Documentary Material at the Science Museum, South Kensington, in October. They are still in good condition though nearly eighty years have passed, and it is believed that modern microphotographs which avoid the use of nitro-cellulose altogether will be even more permanent.

By the middle of the 'sixties the methods of making the tiny *bijoux* had become public property. The secret of success lay in focusing and—perhaps—in the use of the white of eggs. Moreover, it was customary to develop the pictures in as short a time as twenty-five or thirty seconds or even less, thus giving little chance for the silver grains to grow in size. Pieces of glass were first covered with the usual collodion mixture and then, before treating it with a salt of silver, a mixture of various bromides and iodides with sugar candy and the white of egg was carefully poured over the film. After that it was dipped in a silver bath and all was ready.

Results were quite surprisingly successful. By such means as these one side of *The Times* was reduced to the size of a finger nail and yet every word was legible under a microscope. Those who are familiar with the newspapers of last century will know that the size of print used at this period was a great deal smaller than it is to-day, so that this represented no mean achievement.

Indeed, it is only during the last few years, with the advent of "grainless" film, that those early results have been equalled and surpassed.

As we have seen, early microphotography started with no definite utilitarian motive in view. Its very existence was somewhat resented by the orthodox photographer of those days. Thus we find Thomas Sutton, an authority of his time, mentioning the subject in his *Dictionary of Photography* published in 1858. After some quite uninformative remarks, he adds: "Enough has now been said about a process which will strike any reasonable person as somewhat trifling and childish, when he considers how many valuable applications of photography remain yet to be worked out." And this seems to have represented the

opinion of many of his contemporaries. In 1864 we find Dagron complaining that, although microphotography represented quite an industry in Paris, most writers on photography still did not consider it worthy of attention.

But twelve years after Thomas Sutton's work was published, microphotography was destined to find a practical application of no small importance.

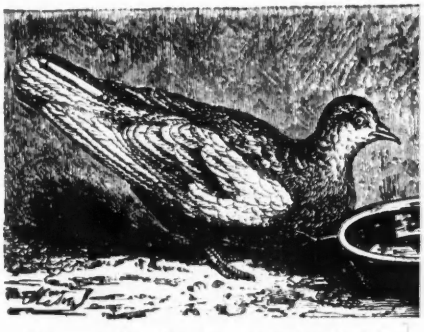
It was in the year 1870 that the Prussian troops were marching irresistibly through France, and soon they reached the capital which they proceeded to surround. Intent upon cutting Paris off completely from communication with the outside world, they dug down to every buried telegraph wire and even dredged in the mud of the Seine for wires of communication. By 21 September they had succeeded in their task and Paris was isolated.

There was no difficulty in sending messages out from Paris for, owing to the prevailing easterly winds, balloons loosed in the city usually came down in friendly territory. Some even landed in England and in *The Times* of 7 February 1871 there is produced an amusing letter from the Rev. A. B. Alexander, Vicar of Christ Church, Churt, in Surrey, who relates that as he was going for a walk one day over the downs he saw "an object which seemed to me to be like a woman with a petticoat, picking up sticks". It turned out to be a "beautiful little crimson-and-white oiled skin balloon" with two letters attached and the request that they should be posted to friends of those who had despatched the message in Paris some days before.

For news in the opposite direction the inhabitants of Paris were forced to rely on pigeons. These were sent out in balloons, and were afterwards released from Tours and other places bearing many a precious military document. But the pigeons were ill-trained for such work, and, with the weight of the paper and the intense cold, it is believed that scarcely one succeeded in reaching the capital.

At this point M. Dagron saw the possibilities of the microphotographic method which he had been perfecting for several years. He proposed its use to the Government, who at once saw its value and made arrangements for M. Dagron to leave the capital. On 10 November two balloons were released from Paris appropriately christened "Daguerre" and "Niepce" carrying Dagron together with much of his apparatus. But the balloons were overburdened and were unable to travel far enough over the enemy's lines. The "Daguerre" was captured by the Prussians and the "Niepce", which carried Dagron, landed in territory which the Prussians had already penetrated. No sooner had its occupants placed the valuable contents in a couple of carts and dressed themselves in the clothes so willingly supplied by the peasants than a group of soldiers appeared and captured one of the carts, together with the balloon. But Dagron showed great cunning and presence of mind. He succeeded in packing his remaining apparatus into wine barrels, after which he obtained a permit from the Prussian military authorities to cross the line into Tours with his wines!

Dagron reached Tours on 21 November, when he proceeded at once to organize despatches to the capital. Copies of documents were printed on thin transparent paper. These were photographed on to a glass slide by the collodion process, and the resulting photograph was once more



Pigeon with quill tube attached to its wing

reduced in size. Finally some three or four thousand messages were all contained on a glass plate less than 2 inches square. From this a large number of copies were prepared and the collodion was stripped off the glass in the form of a thin sheet, but three-quarters of a grain in weight, on which every letter of the original was perfectly reproduced.

About twenty of these pellicles were rolled together and placed in a small quill tube which, when loaded, weighed about a gram. These tubes were attached to the middle feathers of a pigeon which was loosed at Tours.

The only pigeons available were, as we have seen, untrained for the work and very few ever reached Paris, not more than 3 or 4 % in all. But every message was sent out again and again by different birds, perhaps twenty, perhaps fifty times until, as a rule, its reception had been advised by balloon from Paris. In this way fifty thousand despatches reached the city out of a total of about twice that number which had been sent. The total number of messages actually attached to the birds was, of course, a much larger number—about two and a half million.

When the pigeons arrived at their cotes in Paris the quill tubes were carefully opened and, after flattening, they were magnified by an enlarger—which employed a form of electric lamp at that early date. At first the messages were thrown one by one on a screen while clerks copied out the information they contained. This did not prove very satisfactory, however, owing, no doubt, to the poor illumination, and later the messages were projected upon photographic paper directly, and the messages then delivered by post to those for whom they were intended.

Dagron rapidly became more and more skilful in the production of the photographs. Rarely did he delay the messages by more than a day between receiving them and sending them off, while at the end of the siege he was despatching them within five hours. At an early stage the service was made open to the public who were able to send a message of about a dozen words to their friends in Paris at the cost of a franc.

With the advent of wireless, microphotography will never be used in this form again, but mankind is at last awakening to the fact that this long-forgotten method of copying documents may be of the utmost importance to civilization.

Letters from Readers

Water Divining

My attention has been drawn to a statement, in the September number of *Discovery*, that Mr Budgett and I had made water-divining tests in a closed van, and that these tests had shown conclusively that Mr Budgett did not possess the power of detecting water.

This statement was made without my authority, and although the tests provided no evidence in favour of the possibility of water divining, I do not regard them as conclusive, and I intend to continue them with the co-operation of Mr Budgett.

Cambridge E. C. BULLARD

White Helleborine in an unusual form

The white helleborine (*Cephalanthera pallens*), commonly found in beech woods in the South of England, besides elsewhere in the country, is an upright plant normally about 1 ft. to 1 ft. 6 in. high with white flowers and green lanceolate leaves (see illustration).

A colony of this species, visited each summer for several years, has shown a very curious form for the last three seasons. This is smaller than the normal form and is usually "blind", but the great difference is that the whole plant is pure white, without any trace of green colouring matter in the leaves.

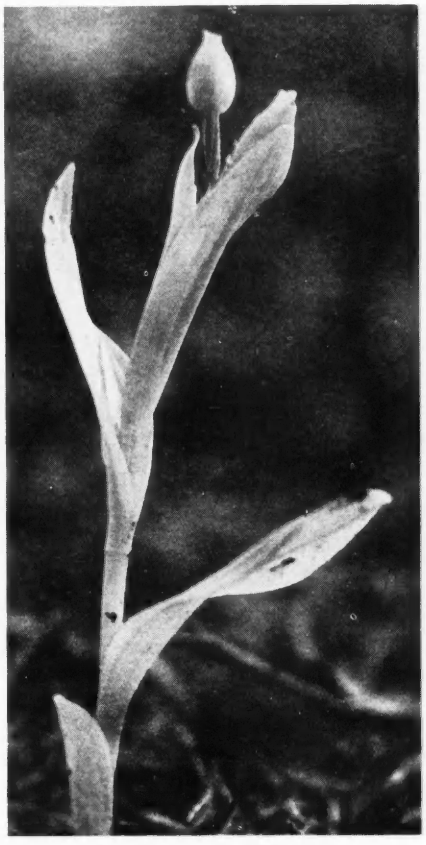
It is known that plants without chlorophyll are generally dependent for their organic food upon the activities of other organisms as parasites or saprophytes.

White helleborine in its usual form

Parasites derive their nutrient materials from the sap of a living host. Saprophytes depend on the activities of minute soil fungi which associate with plant roots in structures known as mycorrhiza.

The plants of the "white" form of helleborine were evidently lacking in chlorophyll and did not appear to be parasitic; examination of their rootstocks seemed to show this. Among the colony of helleborine there grow two known saprophytes—the bird's nest orchis (*Neottia*) and the yellow bird's nest (*Monotropa*); and it may be concluded, therefore, that the soil was already rich in mycorrhiza. Can it be that the plant of the "white" form of helleborine was deriving its nutriment from the organic matter produced by the mycorrhiza fungus? And had it lost its chlorophyll as something no longer necessary?

Romsey, Hants. LANCE DAYL



The unusual all-white form

Lathraea clandestina

I WAS very interested in the letter, published in the October issue of *Discovery*, concerning the finding of *Lathraea clandestina* in Sussex. Last May I was shown some "strange plants" growing on the banks of a small stream in a wood in West Devon. On examination, they proved to be *Lathraea clandestina*.

As your October correspondent points out, the plant is a total parasite on the roots of trees, to which it attaches itself by suckers. A very interesting feature is the method by which it eliminates surplus water. As it has no leaves, the plant cannot do this in the usual way by transpiration; but, instead, makes use of a peculiar subterranean mechanism for the excretion of the excess fluid.

Lathraea clandestina is a native of southern and western Europe. It is by no means sufficiently beautiful to be deliberately brought to this country by plant lovers, so that the manner in which it has travelled so far afield as Devon is by no means clear. Can it be that the seeds have been transported in soil clinging to the wheels of aeroplanes, and which falls off during flight? On the other hand, there is certainly the possibility that its seeds were introduced with the roots of imported young trees, and conveyed many miles by winter floods to the site where the plants were found.

Peverell, Plymouth FRED. C. MARKS

Reviews

Learn about Astronomy

THE very considerable interest which the public of to-day exhibits in the natural sciences extends to the ancient science of astronomy, which is rich in new and important developments in spite of its very long history. This interest is reflected by the number of good books which appear from time to time from which the hitherto uninstructed member of the public can equip himself with some sort of detailed knowledge of the subject. The two volumes at present under review cater for two very different types of enquiry into the science, as the first is a systematic exposition of those remarkable facts and theories which have been produced by astronomers past and present, while the second is designed to help the uninstructed beginner to observe the heavens with modest equipment constructed with his own hands.

Although Dr Waterfield's title restricts him to the developments of the last hundred years, this restriction does little to prevent his book* from being a complete account of astronomy as we now know it. Ancient astronomy is rather a specialized interest, and the sort of work which was really well in hand at the end of the eighteenth century —gravitational astronomy—while it is of very great interest, is probably fairly well known to the scientifically inclined reader, as well as can be managed with the mathematics at his command. Nevertheless, the story of the discovery of Neptune, perhaps the culminating point of the subject, just falls within the last hundred years: so that a study of the astronomy of the last hundred years is practically one of the whole subject. Dr Waterfield's book can accordingly be recommended to anyone who wishes to make a serious attack on providing himself with a thorough working knowledge of modern astronomy and the new science of astrophysics. The book is

* *A Hundred Years of Astronomy*. By R. L. Waterfield. Duckworth. 21*s*.

fairly long—526 pages—and the going is not always easy, so that effort must be expended in mastering its contents. No knowledge of mathematics is assumed by Dr Waterfield, and the mathematical aspects of the subject are not treated; but the nature of the arguments compels some sort of acquaintance with modern physics, which the author does his best to supply.

While it is outside the time, means or inclination of most readers of popular science to acquire a thorough training in mathematical theory or in laboratory methods, it is easy for all to acquire at first hand a little experience of observation: and no amateur of popular science should rest until he has made some move in this direction. The book* by Drs Barton and Joseph is essentially a practical one, and is designed to enable anyone to make his own observations of one kind and another with apparatus made by his own hands. It is indeed surprising how much can be done with very modest equipment. The book is addressed to "Instructors in schools, leaders in activity clubs, guides in scout groups, and counsellors in summer camps", but it can be earnestly recommended to anyone who feels at all interested in science. There can be no question but that the first-hand acquaintance with observation which is afforded by one's own efforts, however elementary, conveys an appreciation of the true nature of science itself, and that popular science of this character is more scientific than "popular".

R. V. D. R. WOOLLEY

A Biochemical Survey for the General Reader

THE authors of this pioneer Survey† are both recognized research workers, and Mr Eggleton is particularly suited to write on "the stuff we're made of". His name, together with that of Grace Eggleton, is connected with the discovery of the compound phosphagen in muscle, a biochemical event which was of decisive importance both for theory and research on the energy supply for muscular contraction.

In 335 pages the writers give a succinct survey of biochemistry and some of its border sciences. The illustrations vary from photographs of an endocrine giant or an avitaminotic pig to diagrams showing little men (hydrogen and oxygen atoms) trying to cross a river by the use of stepping-stones, and hand-rails, symbolizing the function of enzymes and coenzymes. One chapter compares the sizes of molecules with the sizes of bacilli, fleas, rats, the Cheops pyramid, and even the milky way. A description of the principles of scientific method is given, and a demonstration of how the world consists of different elements which combine together in many different ways into molecules: most important from the biochemist's point of view are the protein molecules, and their structures and volumes are more fully dealt with. The living organism is then considered as a heat engine, with subsequent chapters on: "Nature's Use for Overdraft", "Things We Must Eat", "The Vitamin Racket", and "Nature's Stepping-stones" (which means enzymes and coenzymes). Endocrinology and our present knowledge of viruses and phages are then discussed. A final chapter, "Retreat from the Vitalistic", tries to show the inpredictability of the behaviour of soulless particles, thus disposing of vitalism but overthrowing at the same time all purely mechanistic philosophy.

No popular account of biochemistry as a whole has been written before. Easy understanding and readability have been achieved, but not at the cost of exactness, though the desire to make things as easy as possible for the reader here and there leads to a style more familiar on posters of evening papers, and comparisons of organism with the motor-car are, for the same reason, rather abundant. But these are little matters beside the great merits that the book possesses. This is not the place to discuss

* *Starcraft*. By W. H. Barton and J. M. Joseph. McGraw-Hill Publishing Co. 10*s*. 6*d*.

† *The Stuff We're Made Of*, by W. O. Kermack and P. Eggleton. Arnold. 7*s*. 6*d*.

the authors' opinion on the embryonic field theory, or the reason why yeast produces alcohol rather than lactic acid, and so on; though it is fair to add that some biochemists may differ in certain questions from some of the views expressed in the book.

There is one need not quite filled by the book: more attention might be given to the facts known of dynamic biochemistry. *The Metabolism of Living Tissues*, by E. Holmes, which appeared last year, though written for students, suggests that something similar on popular lines would be very attractive. Something along these lines is to be found in the present book in the chapter on "Stable and Unstable States".

H. LEHMANN

A Scientific Encyclopaedia

ALTHOUGH it is impossible for one person to "review" such a book* as this, it is always possible for a worker in a given field to test it according to his knowledge, and to make known the result. In general, this scientific encyclopaedia seems to be no worse than any other of its kind.

But it can hardly be said to be very inspiring. Thus the Witch of Agnesi and Witches' Brooms both appear, but not Witches' Milk, the secretion from the mammary glands of foetuses or newborn infants. Cartesian Co-ordinates and the Cartesian Oval are given, but not the Cartesian Diver, that classical philosophical toy of which the possible uses are by no means exhausted. Coprolites are spelt, in defiance of Greek, Coprelites, as if they were something to do with buffoons. Hormones are said to be always produced in glands. On what principle is Beri-Beri put in and Rickets left out? Why include Fat Body (of insects) and not Omentum? Why should the section on Manometers be written entirely by an engineer, and leave altogether out of account the types used in biology? Why, when Organization and Organogeny are mentioned, omit mention of Organizer phenomena in embryonic development? Worse, there is no mention of Determination, one of biology's most fundamental problems, though Differentiation and Growth both receive moderate attention. Criticism may also be directed to the omission of the words "see" or "cf." in cross-references. Thus we find "Calomel. Mercury" which might mislead the innocent into supposing that the words were synonyms.

On the whole the physical and engineering articles appear to be better than the biological ones, except as regards such subjects as systematic ornithology. While it will certainly do nobody any harm to have this volume within easy reach, it is to be hoped that this is not the best that humanity can do in the way of a scientific encyclopaedia.

J. N.

The Will to Civilization

NO review can pay adequate tribute to a work so vast in subject and in implication as this. The claim that it is "destined to affect very deeply the thoughts and actions of scores of hundreds of men all over the world", is hardly an exaggeration. Of Mr Katz's erudition, insight and competence to deal with the basic problems confronting man to-day and always, there can be no question. The book† cannot fail to interest even the "dilettante"; to make clearer channels of thought which he has not ventured to explore, and to open up new and imposing vistas.

Mr Katz's book is an enlightened survey of the panorama of world history with the purpose of discovering the essential principles of historic change. It does not

* *A Scientific Encyclopaedia*, by D. van Nostrand; edited by twenty-one American scientists. Chapman and Hall. £2. 10*s*. 0*d*.

† *The Will to Civilization*, by John Katz. Secker and Warburg. 12*s*. 6*d*.

confine itself to any limited interpretation; Marxism and Metaphysics come into their proper perspective. The dialectic of essential principles, scientific, moral and religious, is traced, and universal isolates defined, with a view to clarifying the very grave issues before mankind to-day.

Civilization is interpreted as the result of the action and reaction of two great forces, Creativity, the desire for progress and change, and Community, the desire for stability and security. On the successful synthesis of this mighty dialectic, the future of the world depends. Two problems confronted man, how to live with nature, and how to live with his fellow-men. The second, man has not yet solved.

The last chapter, "Towards a New Ideology", is an amazingly lucid exposition of the problem confronting the modern world, in the light of the principles isolated in the preceding chapters. The issue is in doubt between the uncreative Ständestaat and the creative Commonwealth. We are authorized to see in this the conflict between Fascism and Democracy. The cause, says Mr Katz, is a fundamental lack of balance between creativity and community; "Creativity without community can never be an end in itself." Buckle and Herbert Spencer were the ideologists of creative triumphant Capitalism. Their doctrine was rugged individualism, the exaggerated individualism of the twentieth century. Capitalism is a renunciation of community, and, says Mr Katz, ". . unless our ideologists are men of courage inspired by a vision of new and creative civilization that shall take the place of our tired capitalism, they are likely to succumb and to accept baptism into the Fascist creed."

The fear complex conditioning men's minds to-day is only too apparent. It is evidenced in the prevalent defeatism and in the desperate search for absolute values as substitutes for God. "It is only when men are afraid of life that they have a desire to explain everything."

The remedy is clearly indicated in the section in the last chapter entitled, "The Dogma of the Inevitability of Human Failure", and its causes delineated in the chapter "The Sociology of Defeat". "As long as men believe that they must fail, they will fail. The universal commonwealth must be a consciously planned civilization. It can only succeed if men desire it."

One thing Mr Katz makes very clear: that without faith in himself, in nature, and above all in civilization, man must fail. England with its traditions of creativity is, in Mr Katz's view, the ideal leader of the West. Here however the author pauses; he shows what will happen if England does not accept the challenge, and he appears to have confidence in England's ability to fulfil this mission; but as to how England is to set her own house in order, so that she may set about building the highway to world civilization, this point Mr Katz does not develop further. Indeed the "Universal Commonwealth" towards which England must lead can, as he admits, only succeed, "if it is desired by all the peoples of the earth". But how is England to satisfy everyone that she should be the leader?

Mr Katz has a remarkable gift both of analysis and of synthesis; this and the lucidity of his style combine to make "The Will to Civilization" eminently readable, and suitable as much for the student as for the lay reader. No one can fail to find its matter both vital and provocative.

R. O. D. N.

Animal Biology

HERE is an excellent book.* In this, its second edition, Professor Woodruff traces the broad principles of animal biology with an absolute minimum of that mass of detail which, fundamental though it is to the discovery and realization of general principles, tends nevertheless to obscure them by its own profusion. Those who in the past have been discouraged from the pursuit of zoology by the overwhelming collection of

* *Animal Biology*, by L. L. Woodruff (Macmillan, New York, 1938).

names and structural details contained in the average text-book would take fresh courage were they to read Professor Woodruff's bold yet rapid surveys of the invertebrate phyla (chap. VII), and of the vertebrates (chap. IX). Many professional biologists might wish to take the author to task on the grounds that this is a book of sketches, but while he has in truth sketched his subject, he has done so with a firm pen and included an extensive bibliography for those who wish to fill in the finer details. The book is illustrated with many well-chosen drawings and diagrams, and is furnished with a useful glossary.

Professor Woodruff's chapters on "Biology and Human Welfare" (chap. XXIV) and "The Human Background" (chap. XXV) deserve special praise. In them he has dealt admirably and convincingly with economic and clinical applications of biology on the one hand and with the problem of the descent of man—an unfailing source of more purely personal interest—on the other. It is difficult at times like these to escape the conclusion that mankind's worst enemy is man, but Professor Woodruff leaves us more convinced than ever that, could our warfare amongst ourselves be abandoned in favour of a common attack upon our biological oppressors, the history of the human race might be far happier in its future than it has been in its past.

This book is one which ought to be read by professional biologists, but can at the same time be read with interest and enjoyment by the thoughtful layman. It is, moreover, not only a book to read but a book to possess.

ERNEST BALDWIN

Protection from Poison Gas

THESE two books* cover very much the same ground. Both discuss chemical warfare, and both are written by men who have had practical experience of it during the Great War. Perhaps for this reason both authors have a tendency to overestimate the importance of poison gas in air-raids on civilians; gas has so far not been used in the brutal air-raids carried out on Spanish and Chinese cities, and it is generally agreed that the greatest danger to the civilian lies in the high explosive bomb. But poison gas is very much on the public mind to-day (largely because the Government's Air Raid Precaution scheme virtually neglects all other forms of aerial attack) and public ignorance of the properties of poison gases is immense. These books will help to reduce it, since they give good objective accounts of the properties of poison gases, and of the use of poison gas during the Great War. There is throughout, particularly in Professor Kendall's book, a strain of facetiousness which I find irritating.

I get the impression that the critical faculty of the authors is somewhat dulled in the passages dealing with the Government's schemes for the protection of civilians. Both authors write about these in apologetic vein, though Professor Kendall completely destroys the effect which he has created by the following sentence (referring to the "gas-proof room"): "After the Government's air-raid precautions had been condemned as futile, the Government went out of its way to test its own recommendations by a series of the most severe experiments which could be made."

Major Sisson's book has far less digression in it, and sticks more closely to the subject of poison gas. There is bound to be an air of artificiality, however, about any book which deals almost solely with poison gas raids, rather than with air-raids in general. Professor Kendall does discuss other forms of aerial attack, although he does not consider that much can be done to protect the civilian from high explosive bombs. He concludes with the following remarkable passage:

"Don't panic, you always have two chances. There may be another Great War, or there may not. If there is not, there is

* *On Guard against Gas*, by H. A. SISSON (Hutchinson, 2*s.*; pp. 90). *Breathe Freely!* by JAMES KENDALL (Bell, 3*s.* 6*d.*; pp. 180).

"When the clouds watch also, shifting peaceably their place." WORDSWORTH

35-2

no need to panic. If there is, don't panic, you still have two chances. We may be drawn into this next war, or we may not. If we are not, there is no need to panic. If we are, don't panic, you still have two chances. Air-raids on civilians may be renewed, or they may not. If they are not, there is no need to panic. If they are, don't panic, you still have two chances. There may be a raid on the city in which you live, or there may not. If there is not, there is no need to panic. If there is, don't panic, you still have two chances. Bombs may drop near your house, or they may not. If they do not, there is no need to panic. If they do, don't panic, you now have not *two*, but *three*, chances. The bombs may be poison gas, incendiary, or high explosive. If they are poison gas, there is no need to panic; a reasonably gas-proof room and a civilian respirator provide you with double protection. If they are incendiary there is no need to panic even if one falls right through your roof; you can dispose of it calmly with your little bucket and spade. If they are high explosive and fall near enough, you will have no further opportunity for panic...." R. L. M. SYNGE

Select List of Books Received by *Discovery*

(*Mention in this list does not preclude review*)

Biology for Senior Schools. Book Two. M. R. LAMBERT. (Macmillan, 2*s*. 6*d*.)

Your Mind and Mine. R. B. CATTELL. (Scientific Book Club.)

This is Our World. KURT LUBINSKI. (Hodder and Stoughton, 15*s*.)

The Silk Road. SVEN HEDIN. (Routledge, 18*s*.)

A History of Cambridgeshire and the Isle of Ely. (Vol. I, The Victoria History of the Counties of England.) (Oxford, 63*s*.)

Field Determination of Rocks. E. H. DAVISON. (Chapman and Hall, 7*s*. 6*d*.)

Man Against Disease. D. STARK MURRAY. (Pitman, 2*s*.)

Ultrasonics and Their Scientific and Technical Applications. LUDWIG BERGMAN. (Bell, 16*s*.)

Voice Culture Made Easy. J. LOUIS ORTON. (Thorson's, 3*s*. 6*d*.)

Common British Grasses and Legumes. J. O. THOMAS and L. J. DAVIES. (Longmans, 6*s*.)

Through the Garden of Allah. JOHN GRANT. (The Travel Book Club, 3*s*. 6*d*.)

Ascaris: The Biologist's Story. DR RICHARD GOLDSCHMIDT. (English Universities, 10*s*. 6*d*.)

The Household Doctor. (English Universities, 2*s*.)

Teach Yourself Chemistry. JAMES KNIGHT, revised by G. B. MACALPINE. (English Universities, 2*s*.)

Listen! The Wind. ANNE MORROW LINDBERGH. (Chatto and Windus, 7*s*. 6*d*.)

The Handbook of British Birds. Vol. II. WITHERBY, JOURDAIN, TICEHURST, TUCKER. (Witherby, 25*s*.)

The Physical Properties of Colloidal Solutions. MAY ANNETTS SMITH. (Longmans, 15*s*.)

Galileo and the Freedom of Thought. F. SHERWOOD TAYLOR. (Watts, 7*s*. 6*d*.)

Fore-Knowledge. H. F. SALTMARSH. (Bell, 3*s*. 6*d*.)

Southern Lights. JOHN RYMILL. (Chatto and Windus, 31*s*. 6*d*.)

Children of Tane. MONA GORDON. (Dent, 10*s*. 6*d*.)

The Microscope Made Easy. A. LAURENCE WELLS. (Warne, 3*s*. 6*d*.)

Witchcraft in the Star Chamber. C. L'ESTRANGE EWEN. (3*s*. 6*d*.)

Every Boy's Book. H. L. GEE. (University of London Press, 5*s*.)

Glories of the Maya. THOMAS GANN. (Duckworth, 18*s*.)

The World's Airways. ROBERT FINCH. (University of London Press, 5*s*.)

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By CHARLES REITH

8s. 6d. net

"...Mr Reith's book is not only a fascinating story in itself, but it is a warning of the results of national and international anarchy, and a reminder of the ineptitude with which all reformers have to cope...."

HAROLD NICOLSON in *The Daily Telegraph*

OXFORD UNIVERSITY PRESS

Suggestions for Christmas Book Gifts

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A fast-moving and exciting thriller by the author of "Grim Chancery", that fully justifies the slogan "Mill's for Thrills". 7/6 net

NELSON

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You can't come home at eleven o'clock and switch on your wireless to hear the talk broadcast at eight. But wouldn't it be convenient if your set could, as it were, "keep it hot" for you. Impossible, of course, but you can have the actual words that were spoken, because the pick of the talks are published in "The Listener".

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by L. J. M. COLEBY

This book is not only an account of Macquer's life and work, but also of the state of chemistry in France in the middle of the eighteenth century. Macquer, born in Paris in 1718, is well known for his researches on Prussian blue and on arsenic. He was the author of the first *Dictionary of Chemistry*, a work which was immediately successful. *6s. net*

Copernicus: The Founder of Modern Astronomy

by ANGUS ARMITAGE

This book sketches the career of the greatest of sixteenth-century astronomers against the stormy political background of his time, and explains in detail the contents of his historic book, from which we have derived our modern conception of the solar system. *10s. net*

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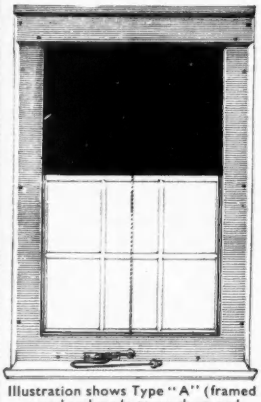

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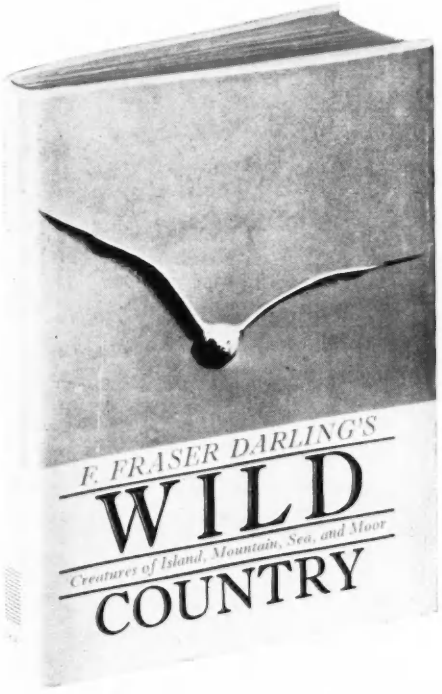

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